Environmental Engineering

Prof. Jennifer Jay
Ph.D. student Ileana Callejas

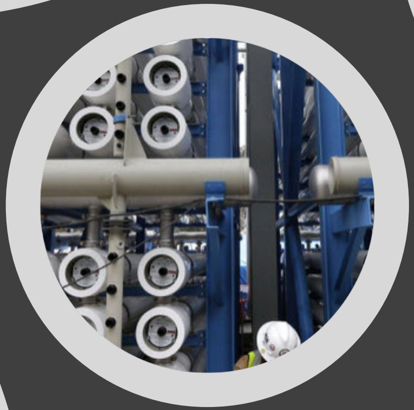
CEE1 10/29/21

UCLA Samueli School of Engineering

What do environmental engineers do?

We address local and global environmental problems!

UCLA



We work in natural and engineered systems.

Our Team of Faculty

Assessment/ Prevention

Treatment

Remediation

Jenny Jay

Sanjay Mohanty

Michael Stenstrom

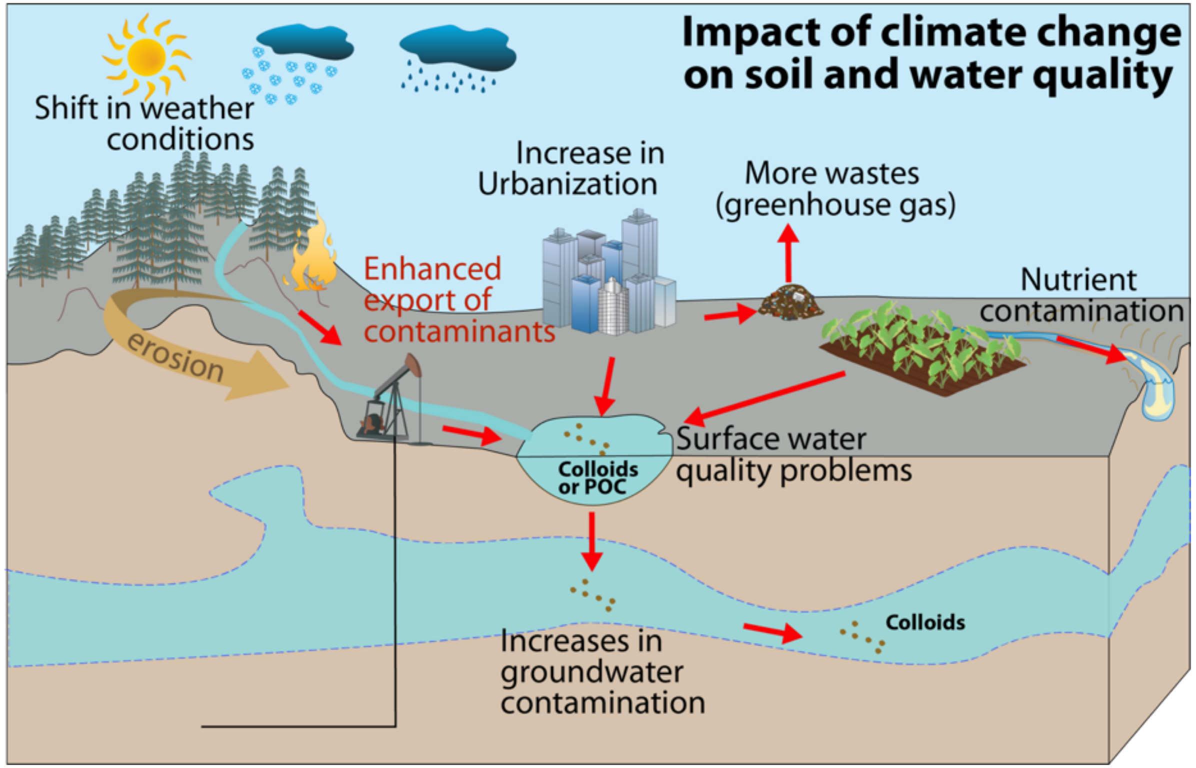
Eric Hoek

Shaily Mahendra

David Jassby

Mohanty Research Group

Overarching Research Goals



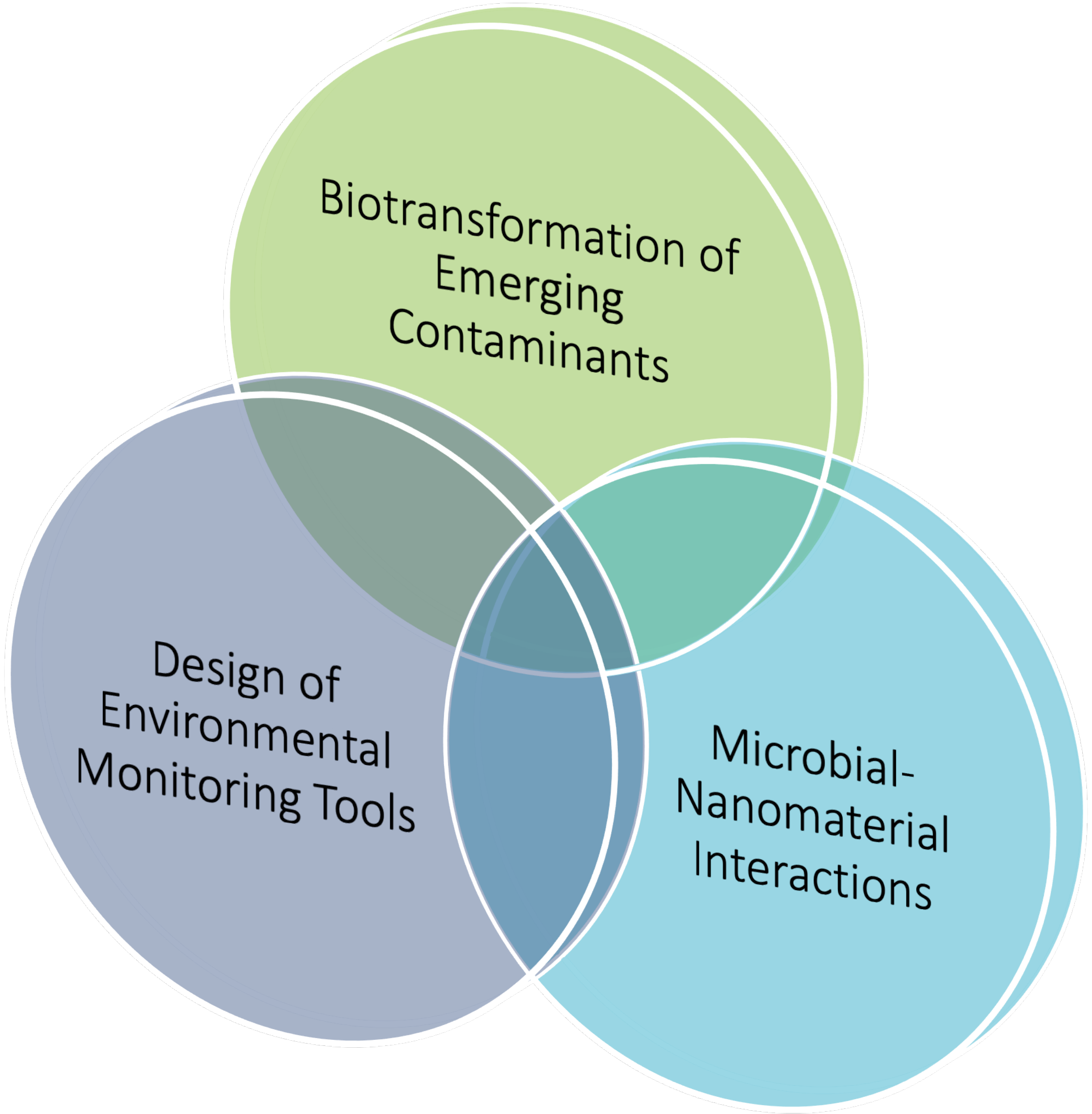
Examine the links between climate change and water quality degradation.

Whether and how climate change mediated varying weather conditions affect contaminant removal processes in subsurface soil.

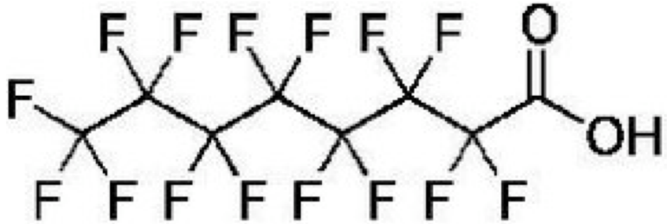
Develop the design of a "self-cleaning or rechargeable biofilter"

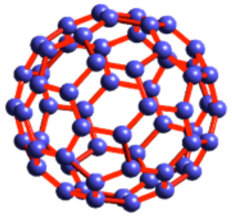
To increase the resiliency of green infrastructure and develop a viable technology in achieving water sustainability.

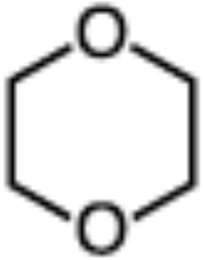
Research in Mahendra Laboratory



Emerging Water Contaminants







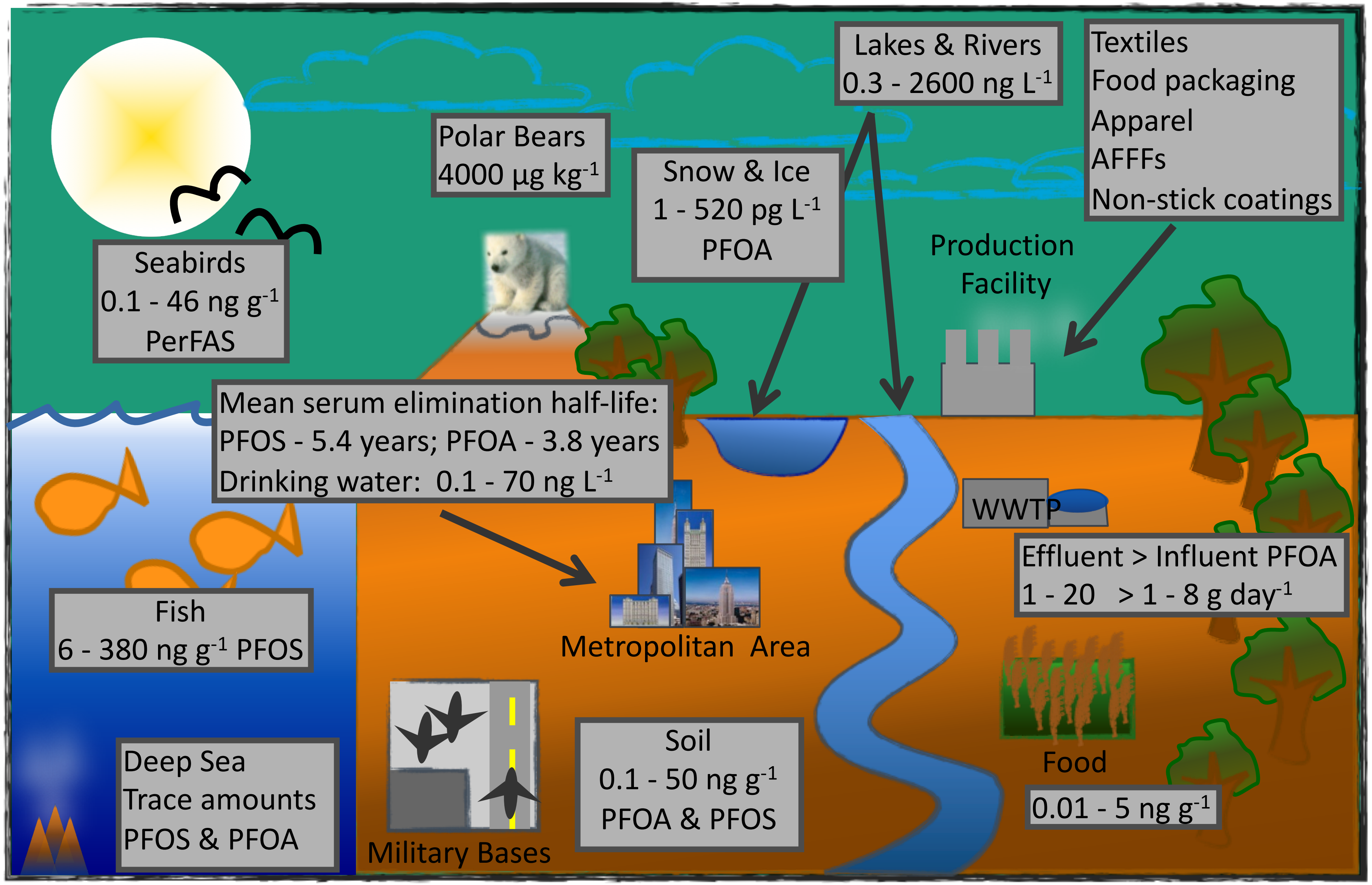
Polyfluorinated Substances

Nanomaterials

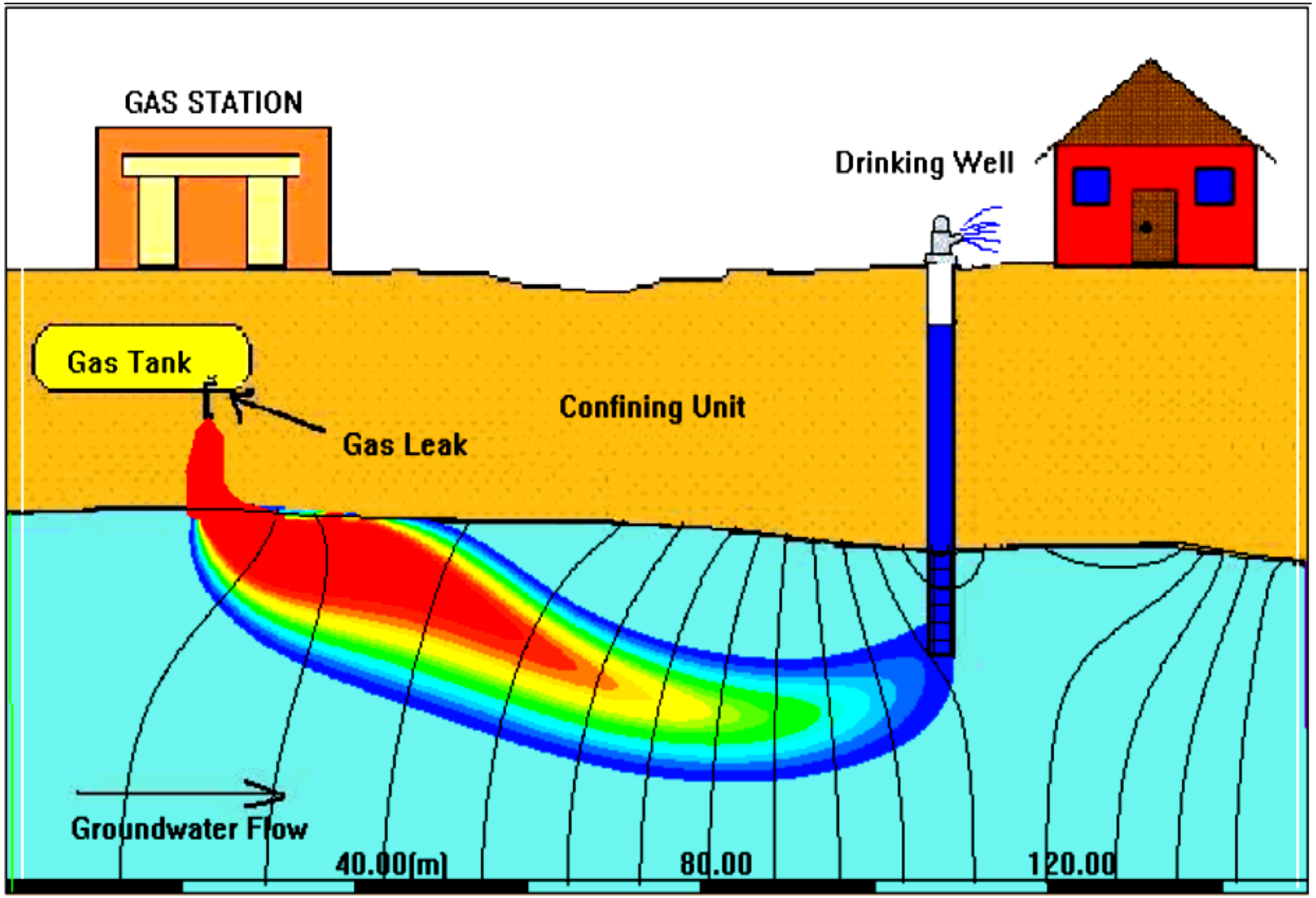
1,4-Dioxane

Polyfluorinated substances are in your home!

These chemicals are found everywhere!

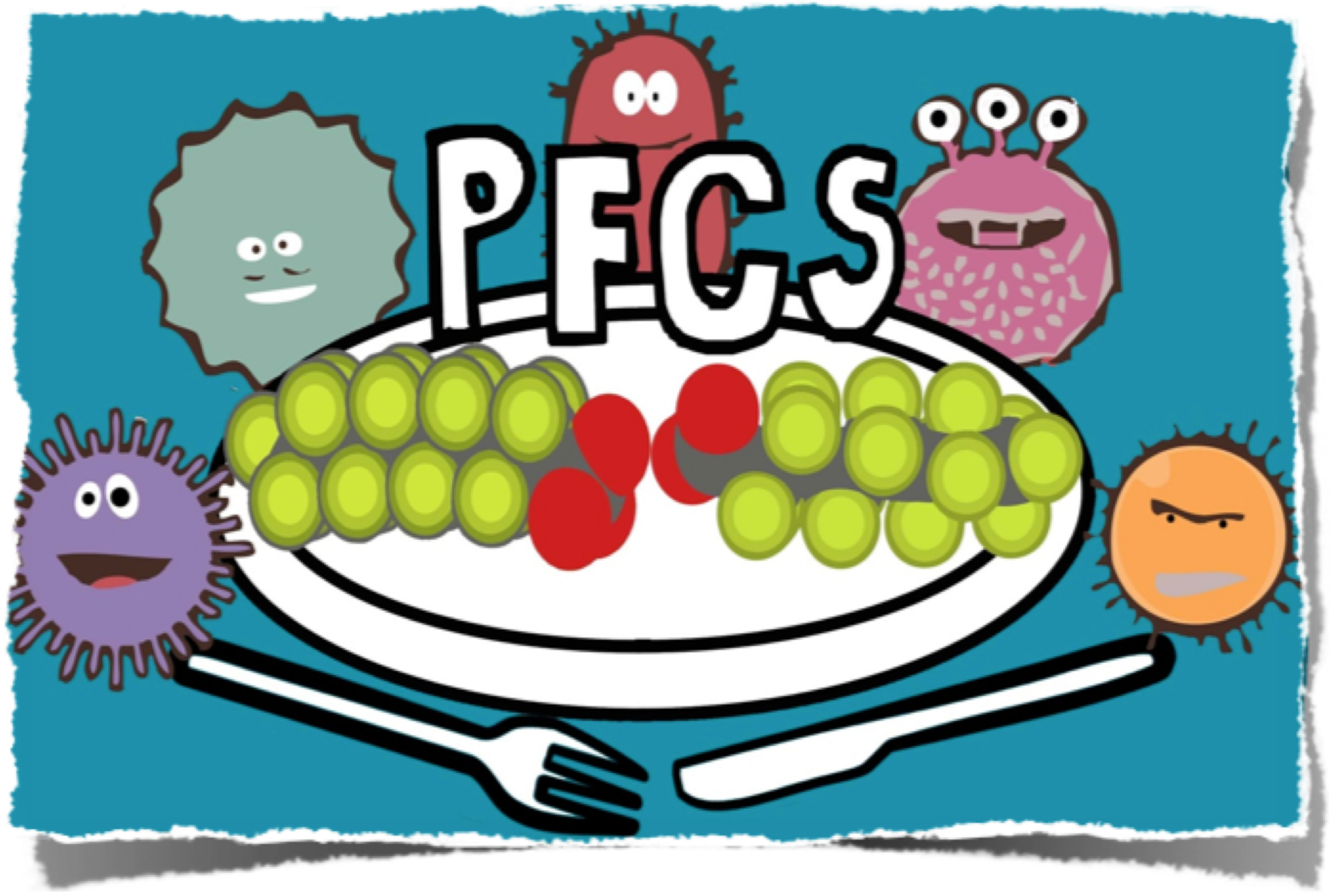


Polluted soil and groundwater!



http://www.egr.msu.edu/igw/DL/index.htm

Biodegradation of Poly- or Per-FAS?



$$

Ambient

Less Toxic

In-situ

Antibiotic resistance is now a global threat to public health!!

The development of antimicrobials over the 20th century lead to *incredible improvements in medical care.*

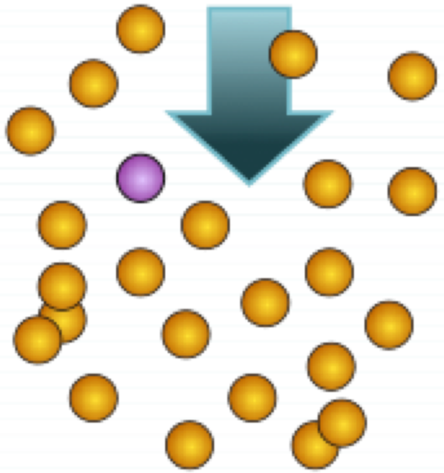
According to the World Health Organization, antibiotic resistance "*threatens the achievements of modern medicine*"

Source: World Health Organization, 2014

IFAP impacts to public health

Antibiotic resistance

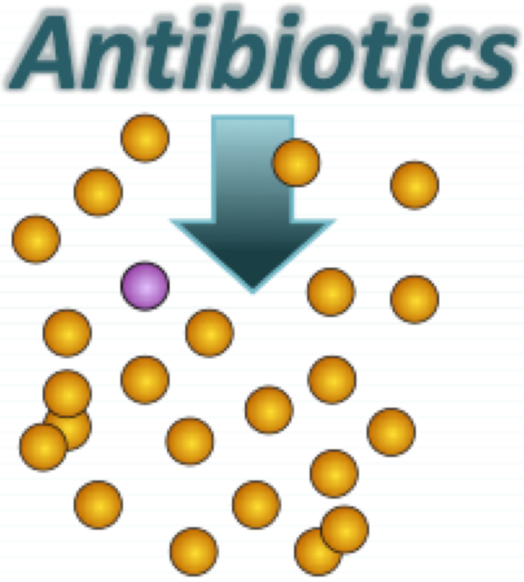
Antibiotics



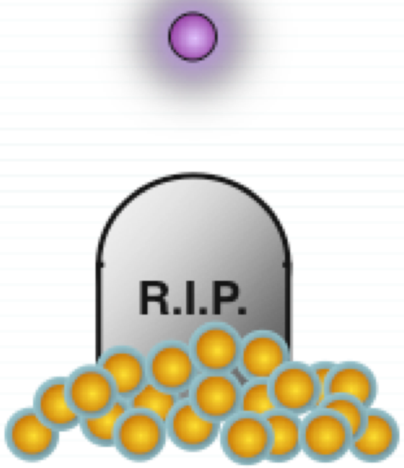
1. Pathogens are routinely exposed to antibiotics

IFAP impacts to public health

Antibiotic resistance



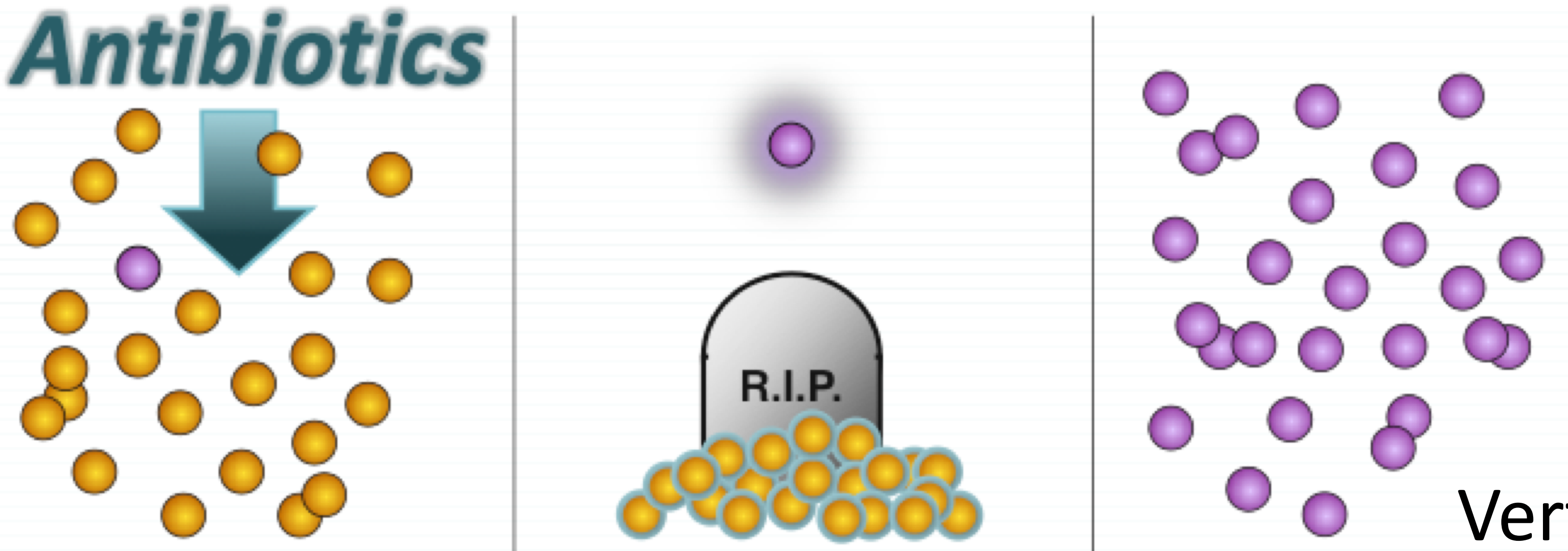
1. Pathogens are routinely exposed to antibiotics



2. **Susceptible** pathogens die, **resistant** pathogens survive

IFAP impacts to public health

Antibiotic resistance



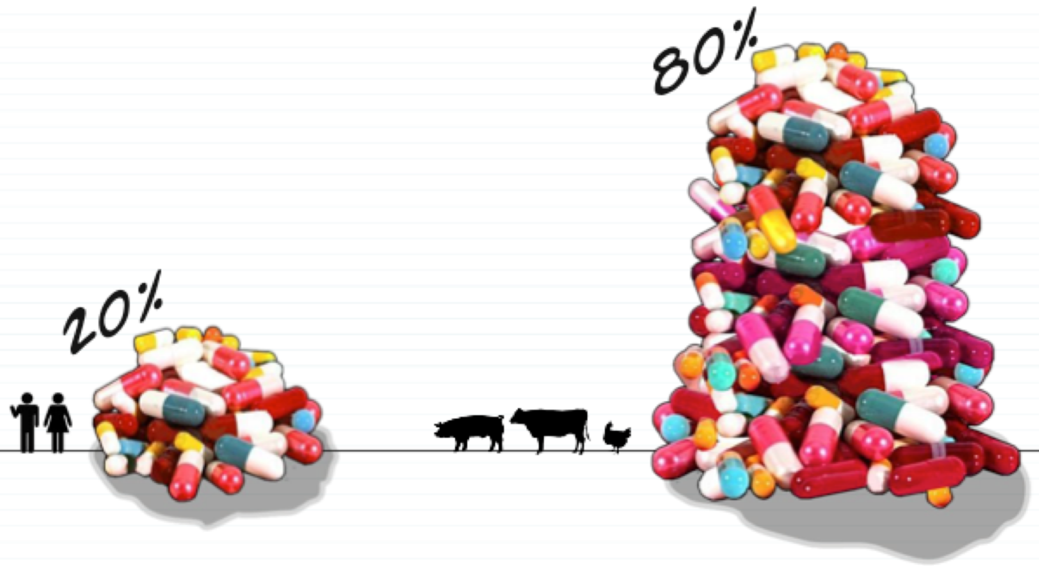
Vertical gene transfer

1. Pathogens are routinely exposed to antibiotics
2. **Susceptible** pathogens die, **resistant** pathogens survive
3. **Resistant** pathogens multiply

What is the largest use of antibiotics currently?

IFAP impacts to public health

Antibiotic use in the U.S.

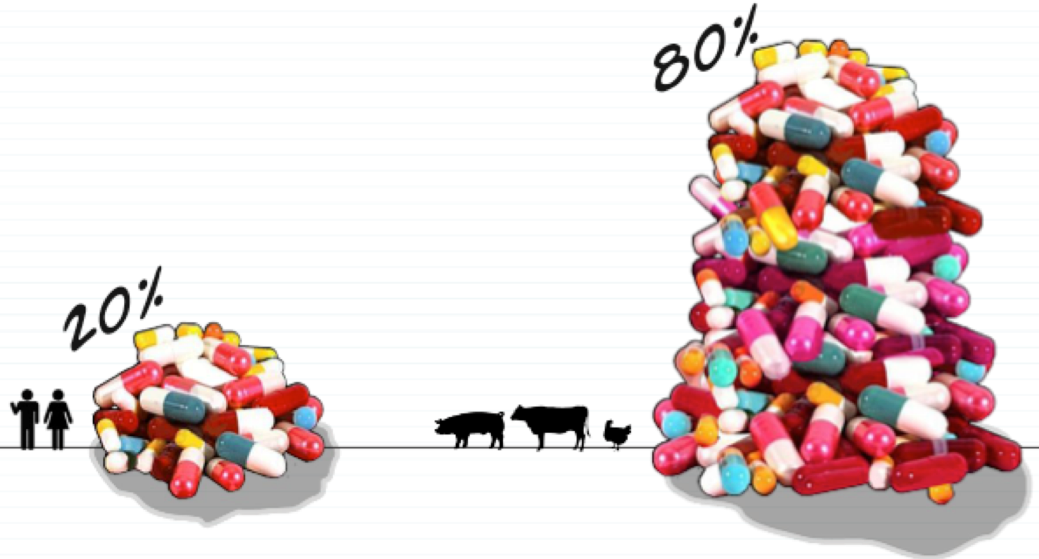


	Human use	**Animal use**
Annual distribution:	3.3 million kg	13 million kg

Kim B. Johns Hopkins Center for a Livable Future; 2011.

IFAP impacts to public health

Antibiotic use in the U.S.



	Human use	Animal use
Annual distribution:	3.3 million kg	13 million kg
Primary use:	Treat disease	Promote growth

Kim B. Johns Hopkins Center for a Livable Future; 2011.

IFAP impacts to public health

Wasteborne contamination

(Images not to scale)

Human waste

Generated each year: 7 million dry tons

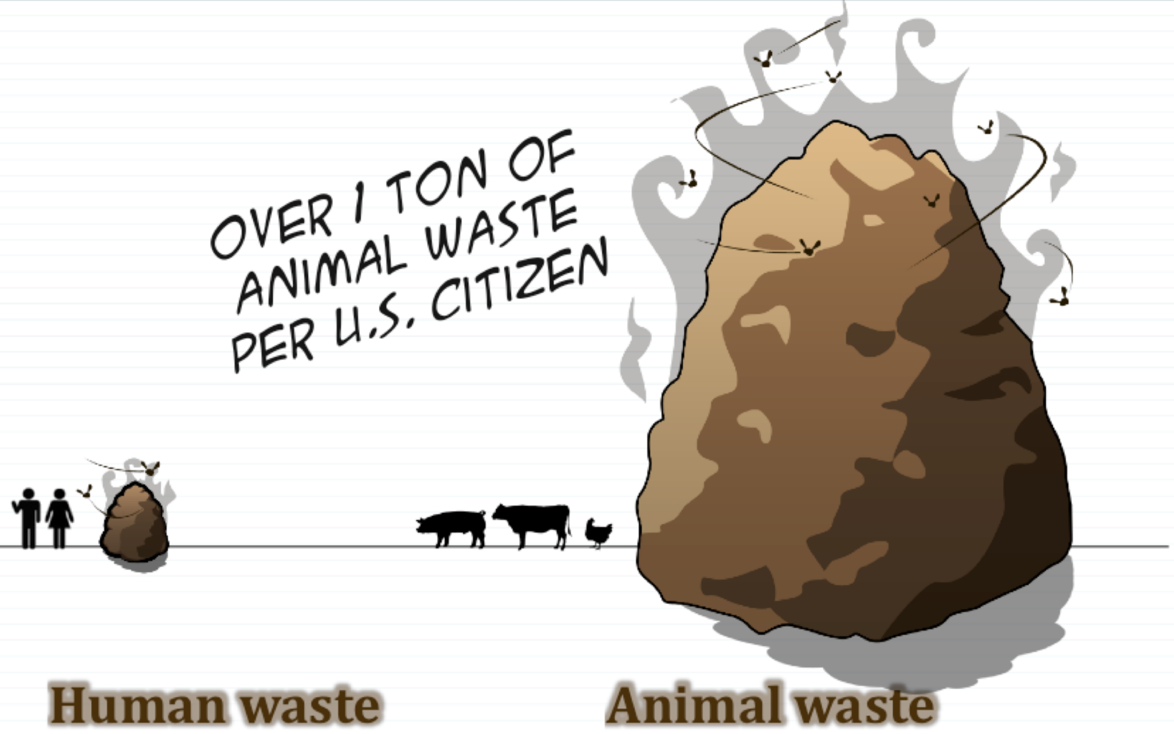
Applied as fertilizer: 4 million dry tons

Kim B. Johns Hopkins Center for a Livable Future; 2011.

IFAP impacts to public health

Wasteborne contamination

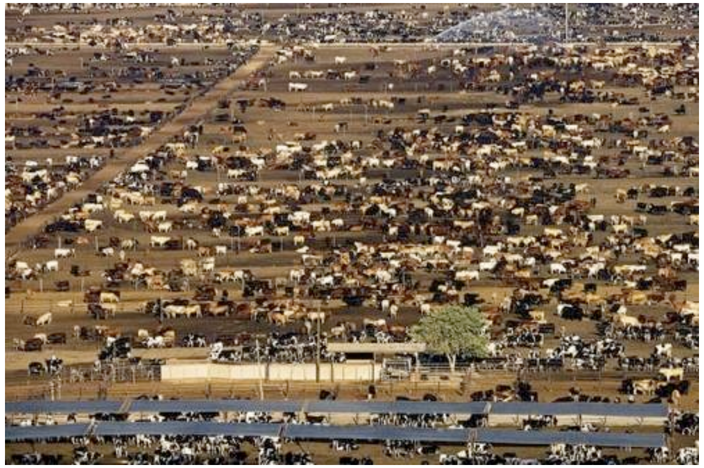
(Images not to scale)



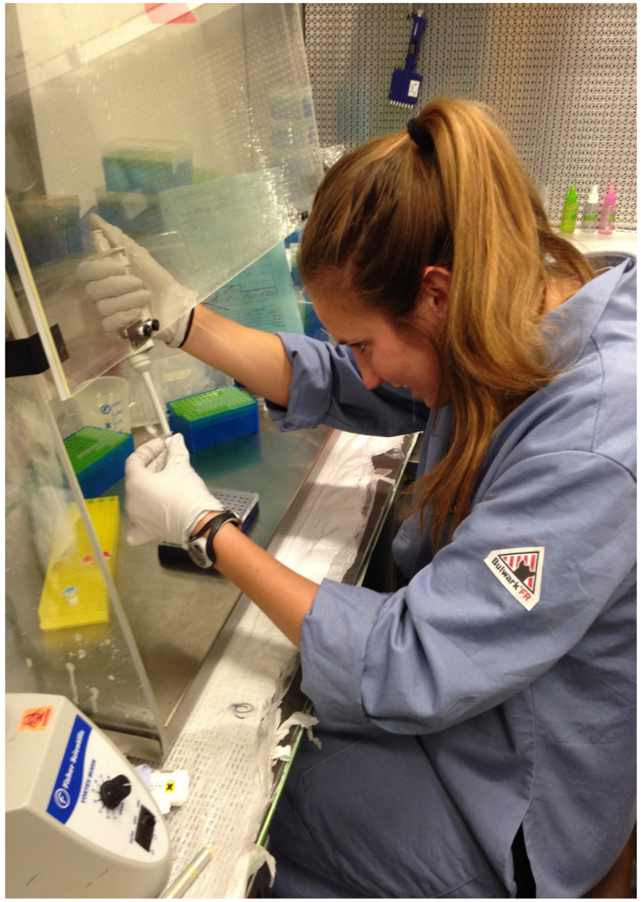
	Human waste	Animal waste
Generated each year:	7 million dry tons	287 million dry tons
Applied as fertilizer:	4 million dry tons	270 million dry tons

Kim B. Johns Hopkins Center for a Livable Future; 2011.

Comparison of airborne antibiotic resistance genes and antibiotic resistant bacteria near cattle farms

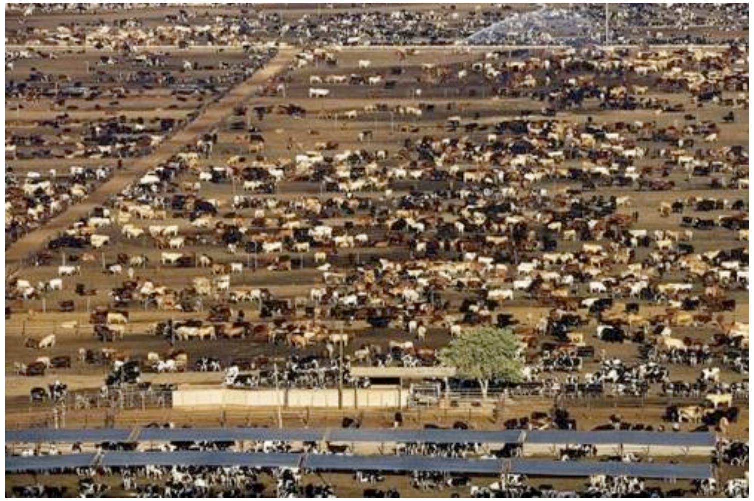


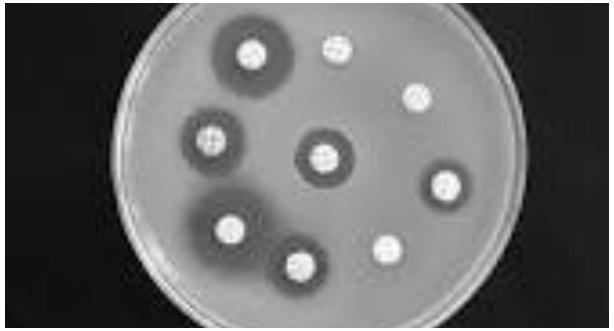
Collected air at three feedlots and three organic farms.



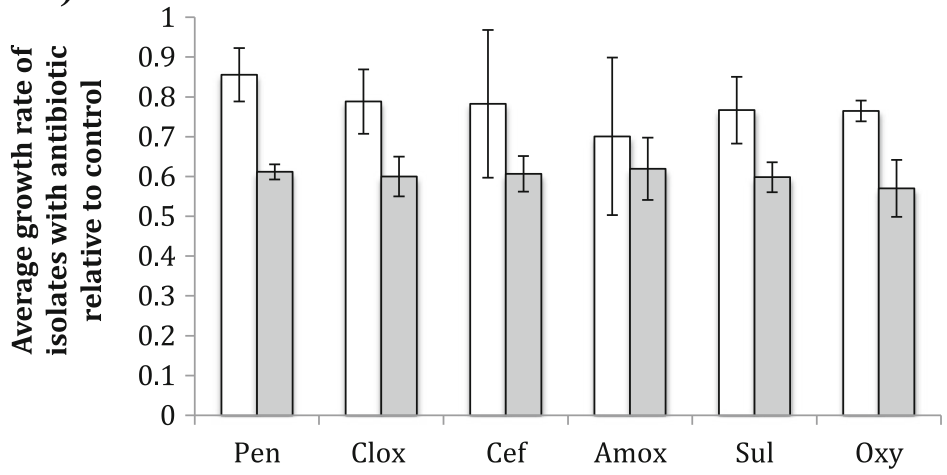
Tested 1,200 isolates for antibiotic resistance

Elevated antibiotic resistance observed near feedlots relative to pastures.

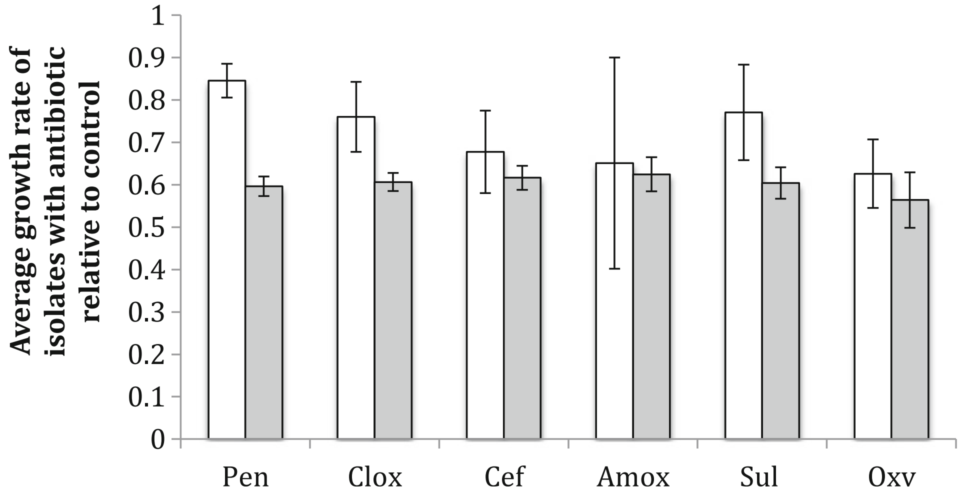




A)

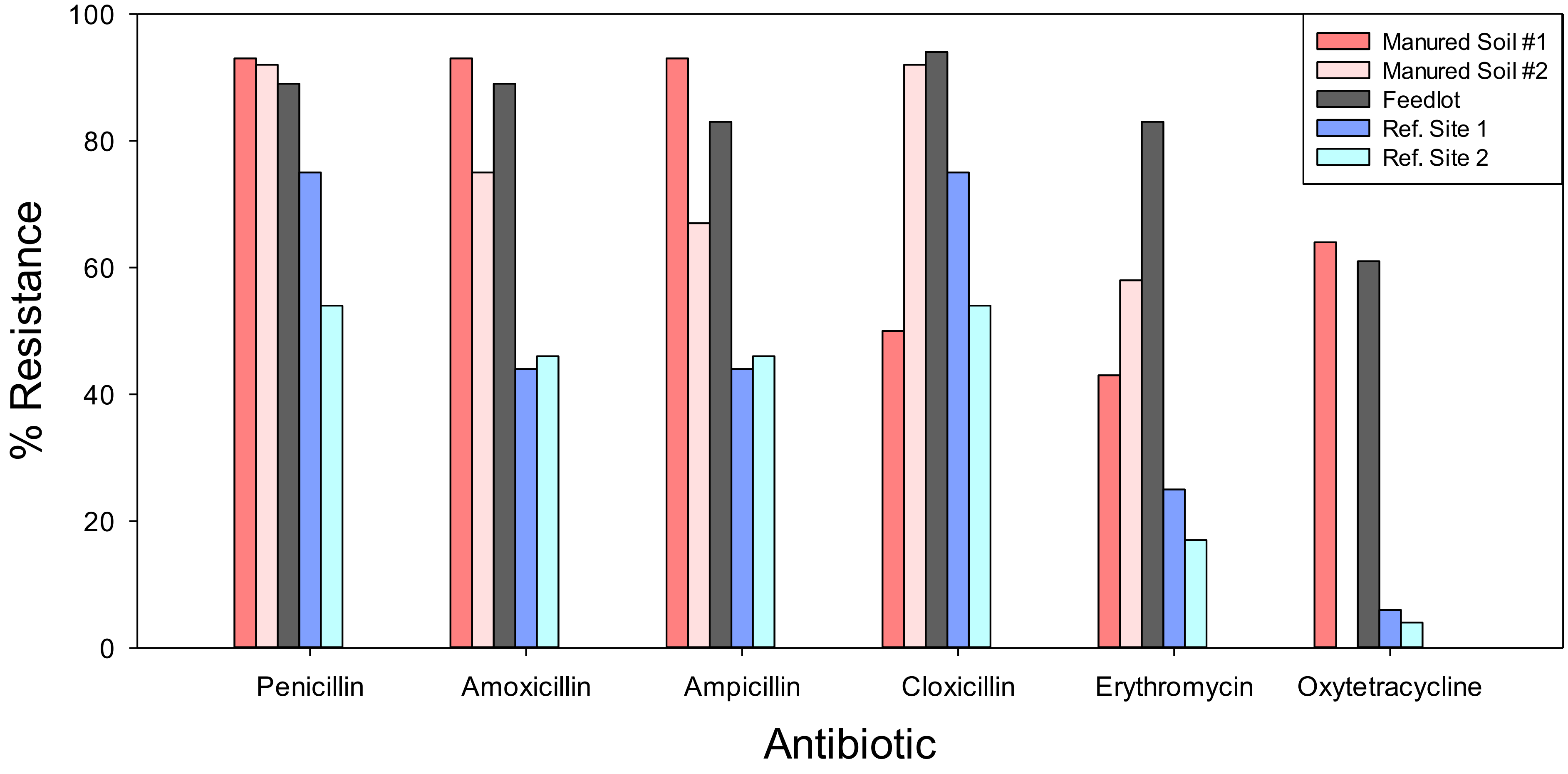


B)



Unfilled and filled bars show the average of three feedlots and organic farms respectively.

Air-borne bacteria collected near manured fields had high levels of antibiotic resistance



Retail Chicken Project

Conventional

No Antibiotics

Humane Family Farm

What would be your hypothesis about antibiotic resistance in *E. coli* from these products?

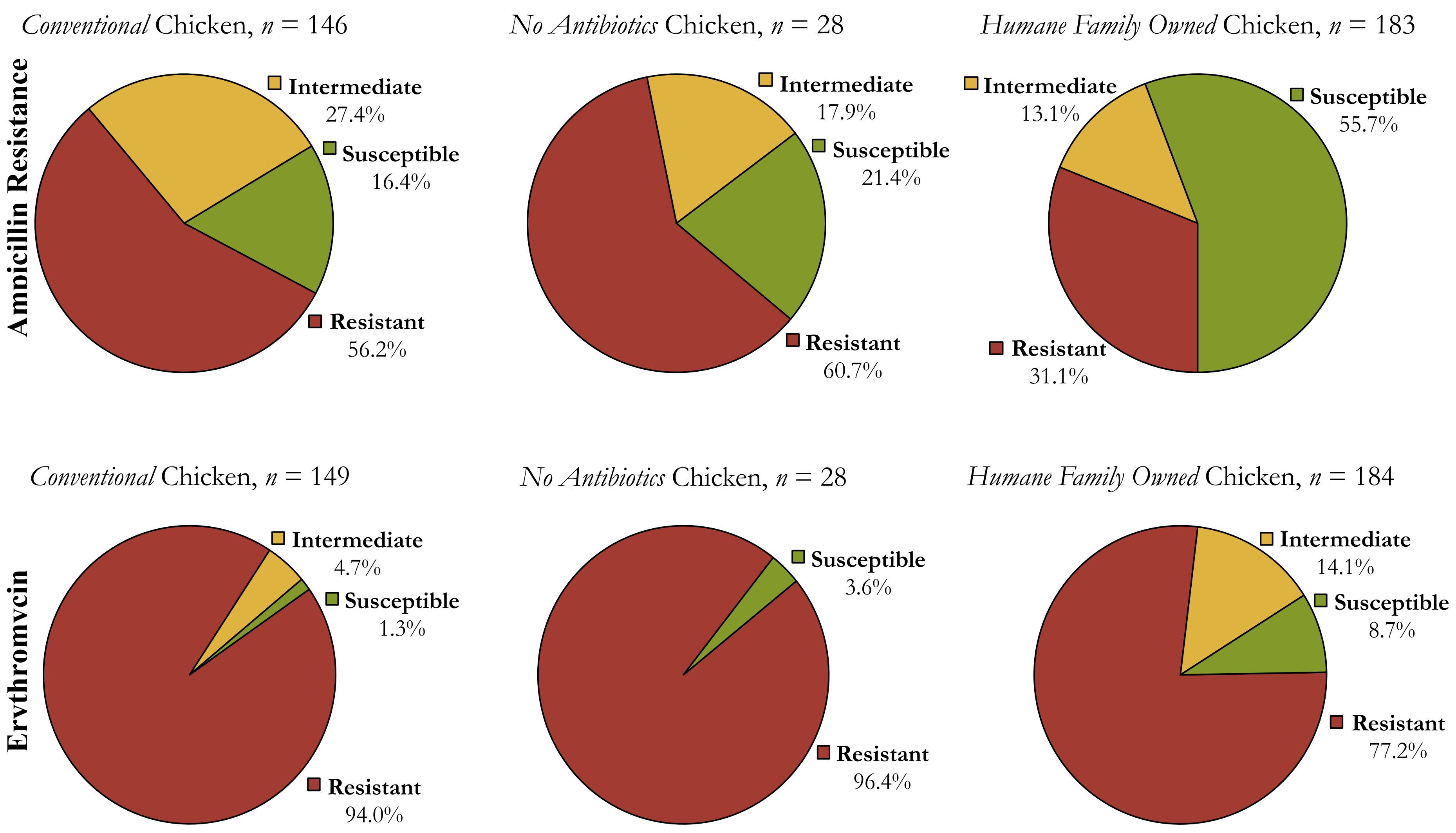
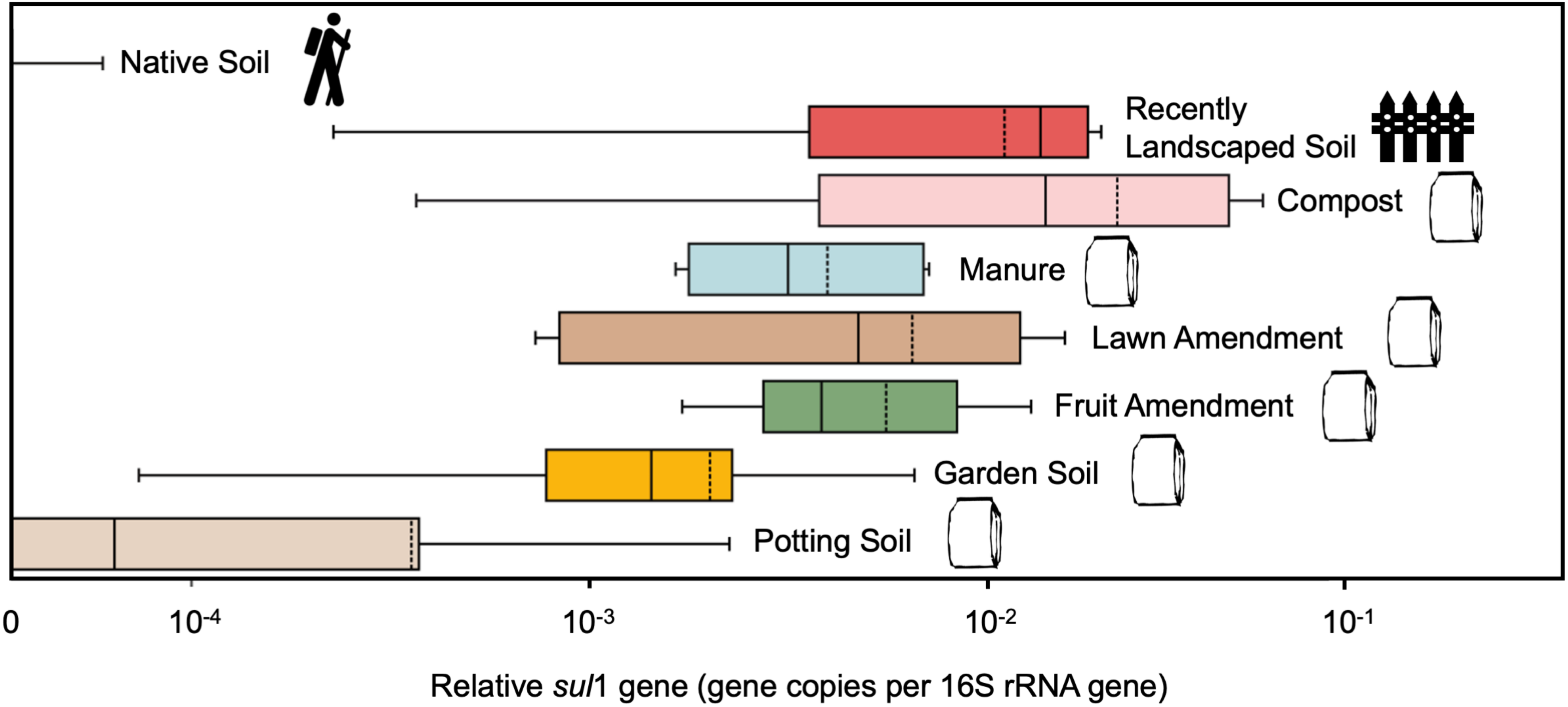


Figure 1. Pie charts showing the percentage of resistant, intermediate, and susceptible isolates for each of the three production categories of chicken—*Conventional*, *No Antibiotics*, and *Humane Family Owned*. (**a**,**b**) demonstrate resistance and susceptibility to ampicillin and erythromycin, respectively.

What do these graphs tell you?

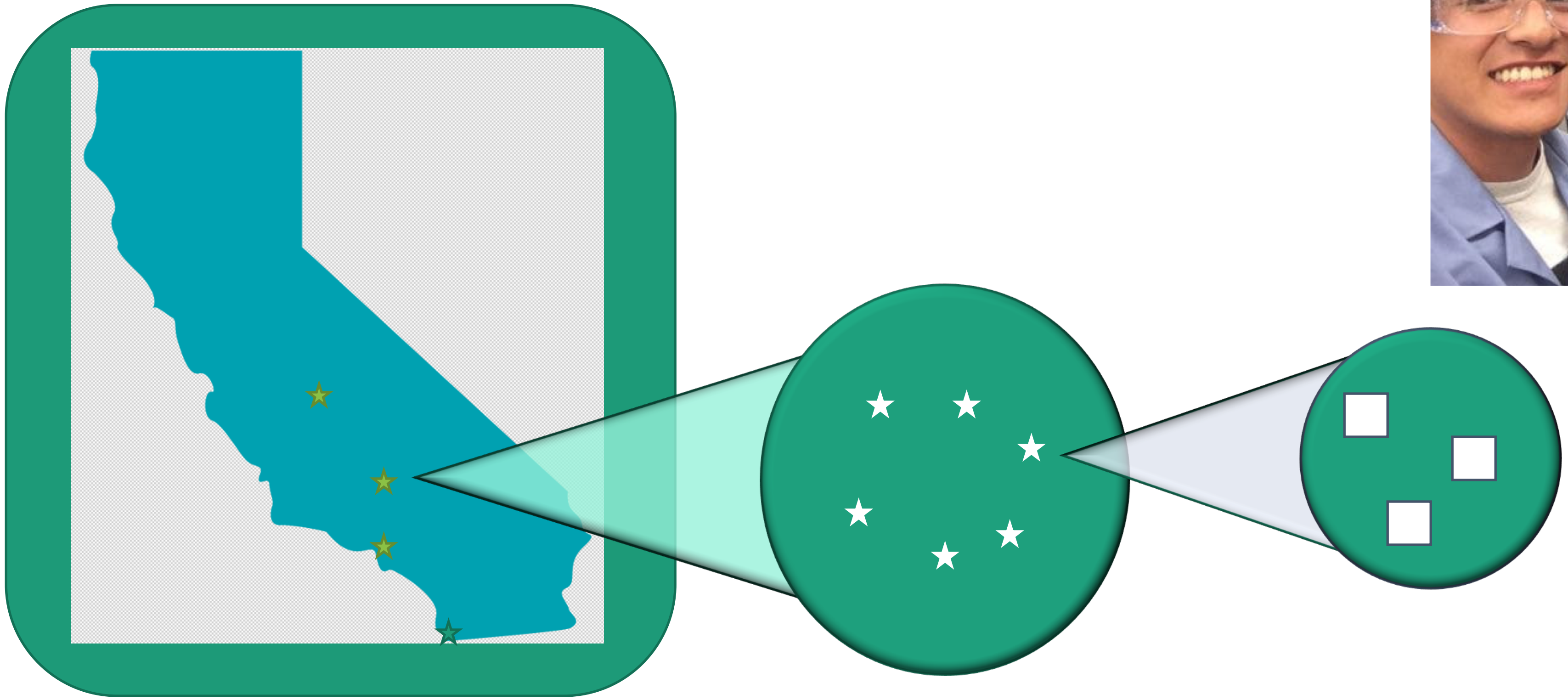
Sanchez et al. 2020

Fertilizer Team



Native Soil
Recently Landscaped Soil
Compost
Manure
Lawn Amendment
Fruit Amendment
Garden Soil
Potting Soil
0
10-4
10-3
10-2
10-1
Relative sul1 gene (gene copies per 16S rRNA gene)

Regional study of Antibiotic Resistance



Four cities

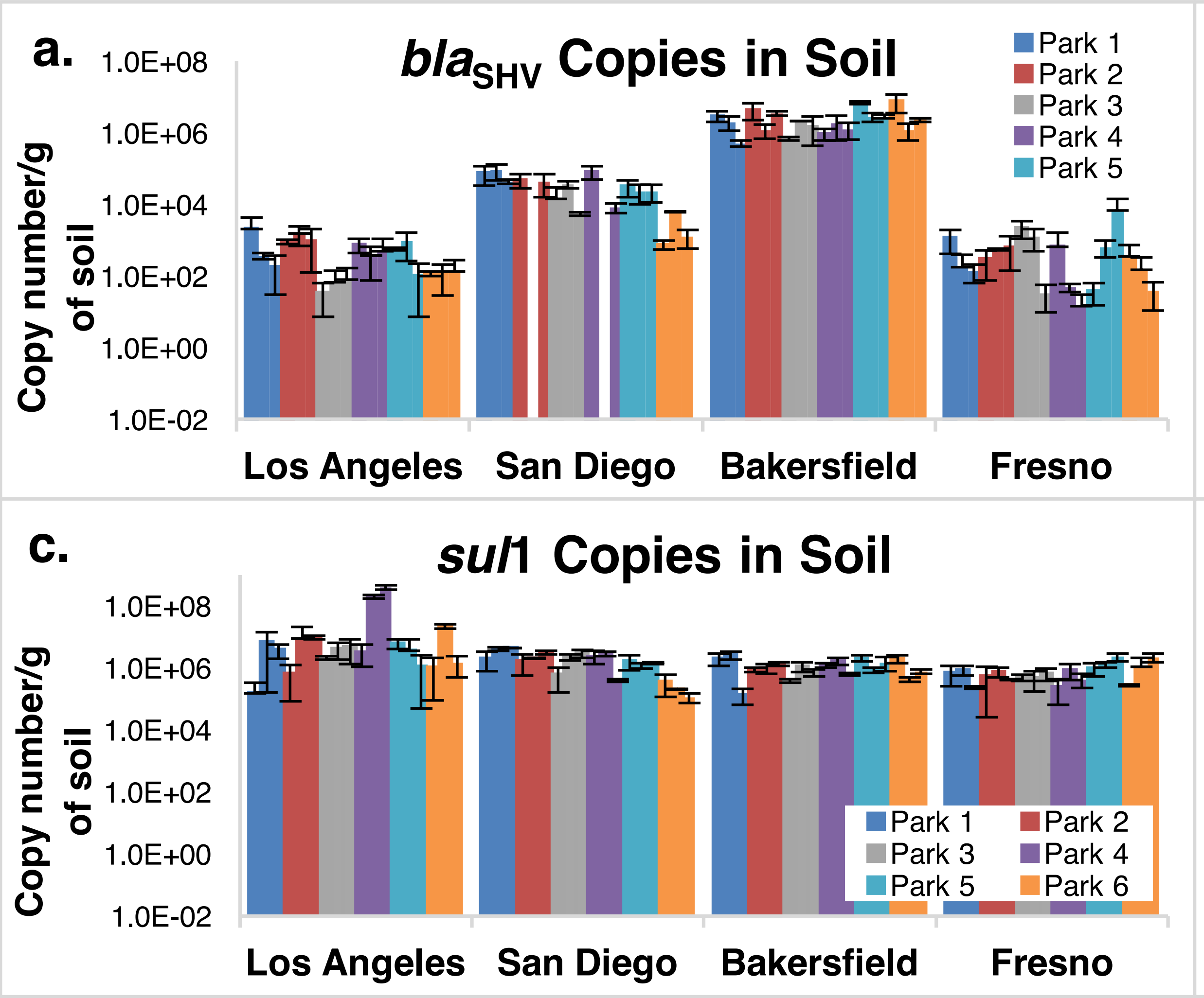
Six parks per city

Three samples per park

Methods: Sample Collection

- Soil
- Water
- Air

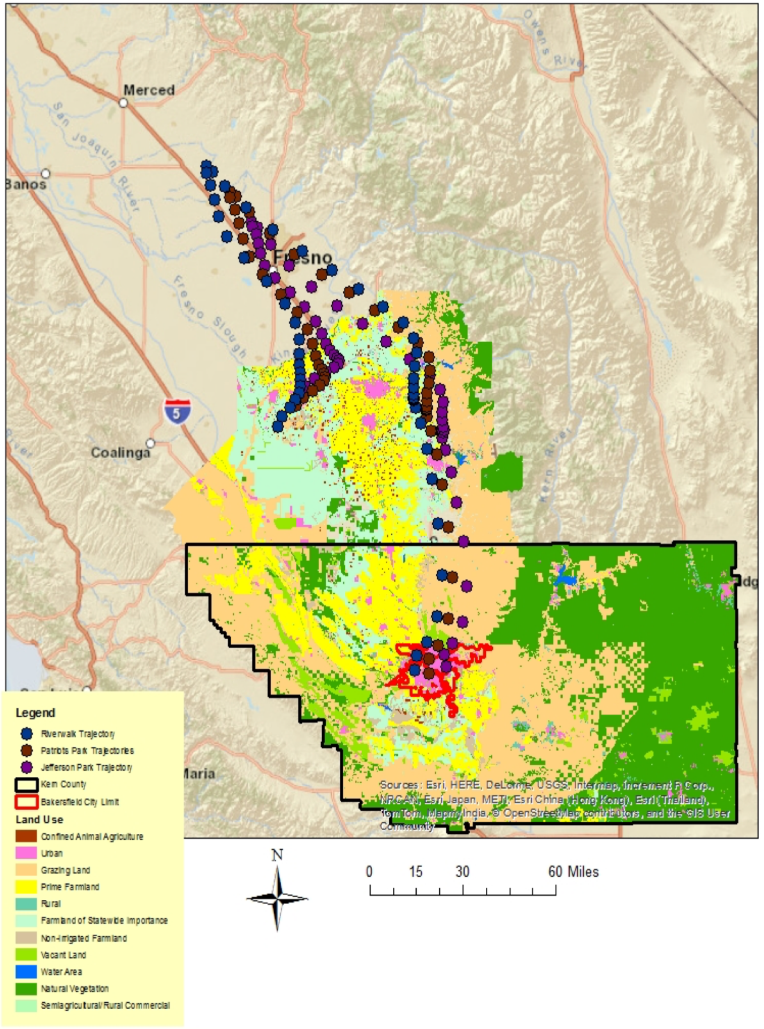
ARG levels in soils (per gram of soil)



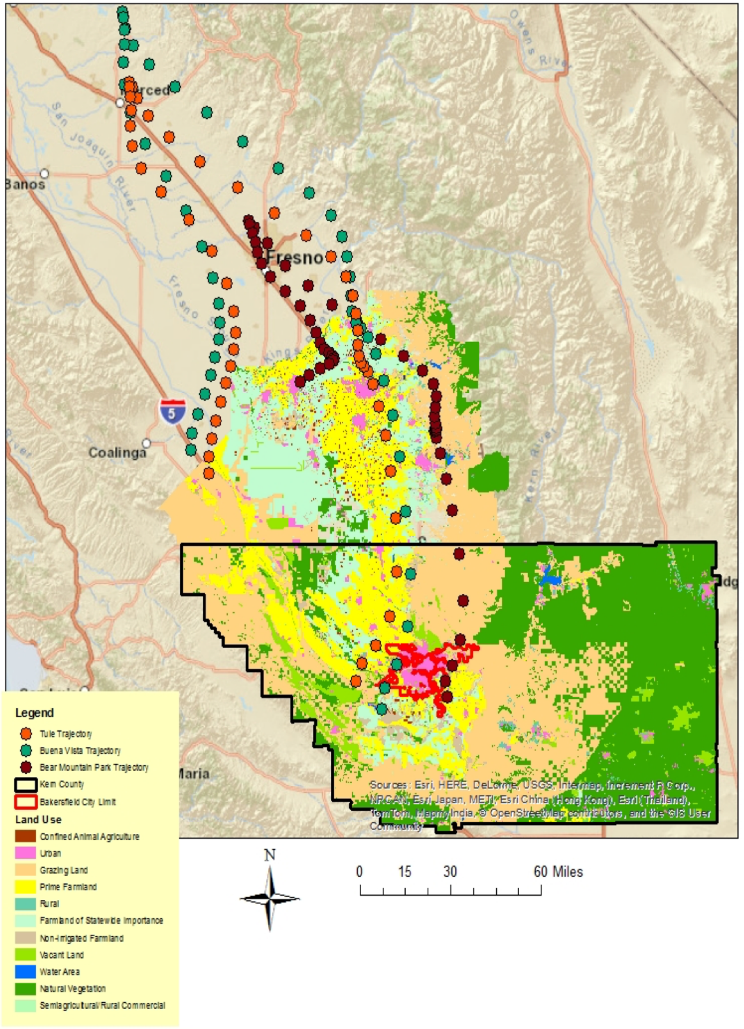
Echeverria et al. 2017

HYSPLIT to Analyze Wind Patterns

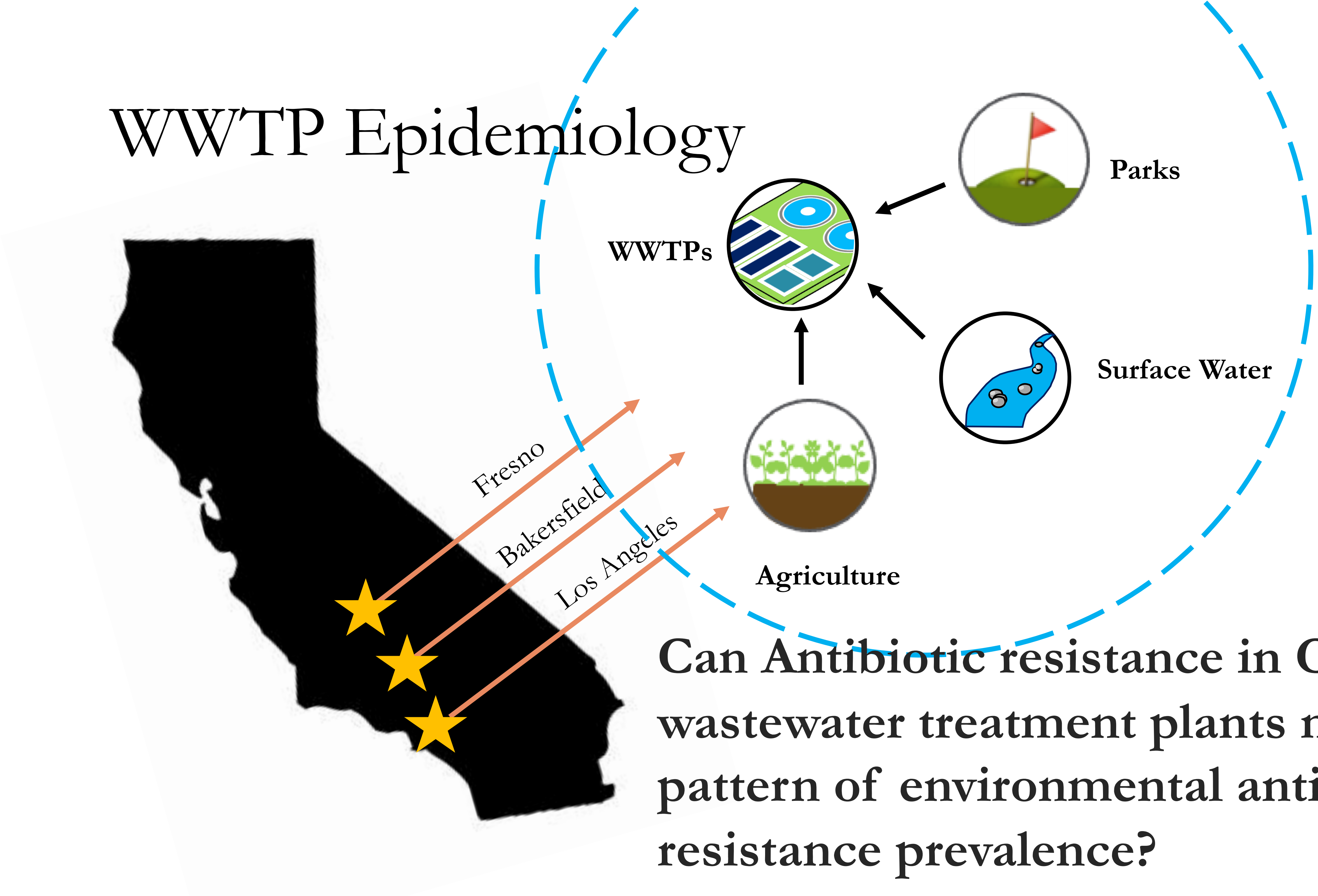
Urban Park Trajectories



Agricultural Park Trajectories



WWTP Epidemiology



Can Antibiotic resistance in Californian wastewater treatment plants mirrors the pattern of environmental antibiotic resistance prevalence?

Working and living in proximity to farms and manured fields is associated with:

Increased:

- **Colonization with antibiotic-resistant pathogens including MRSA**
- **Skin infection**
- **Soft tissue infections**

Selected sources: Casey et al., 2013; van Dijk et al. 2016; Carrel et al., 2014; Bisdorff et al. 2012; and Feingold et al. 2012.

Critical Gap in Literature:

Prospective studies showing colonization following exposure

https://www.mtpr.org/post/hidden-costs-cafos

Surfer Resistance Project

UCLA

Sea Grant
University of Southern California

SURFRIDER FOUNDATION
Los Angeles Chapter

UCLA Samueli School of Engineering

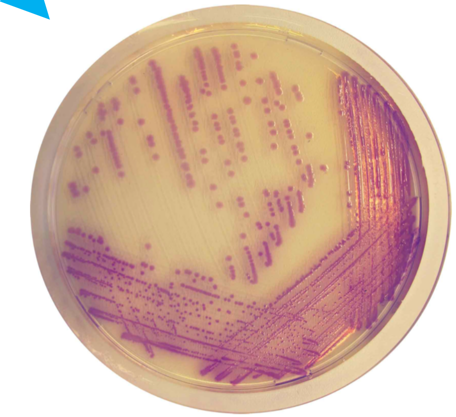
UCLA Institute of the Environment and Sustainability

Heal the Bay

Are surfers getting colonized or infected by methicillin-resistant *Staphylococcus aureus* MRSA by surfing in Los Angeles?

Marine water collection at sunrise

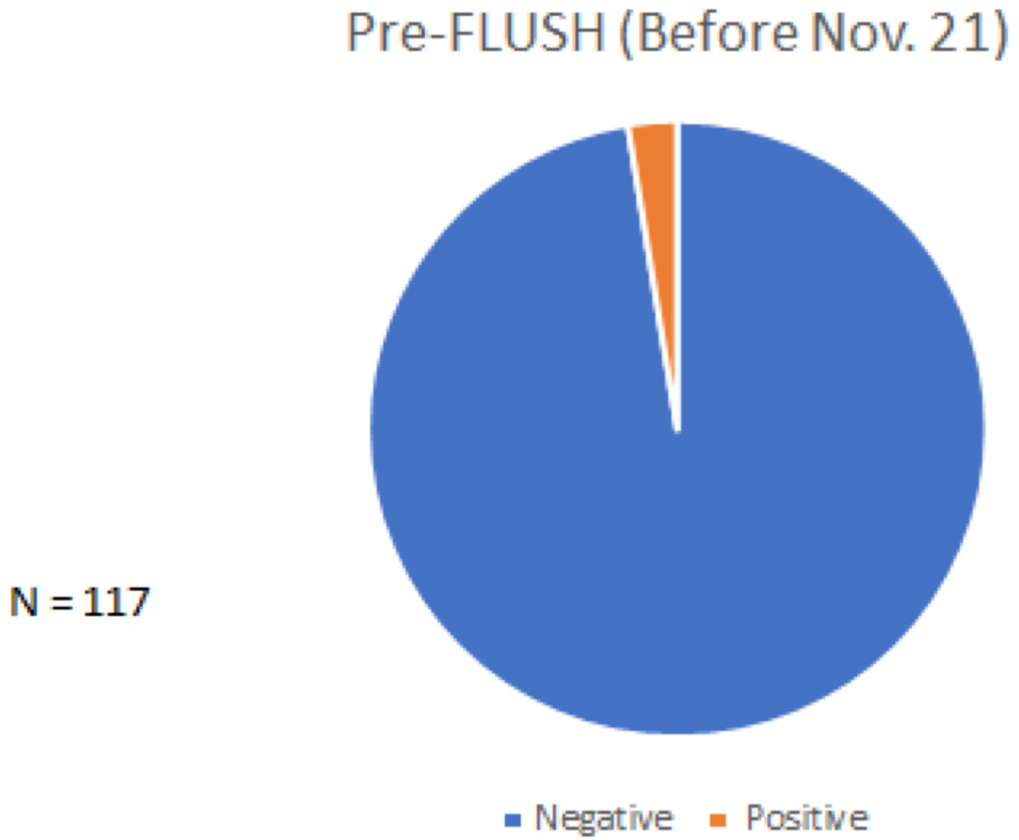
Surfer swabs and health surveys

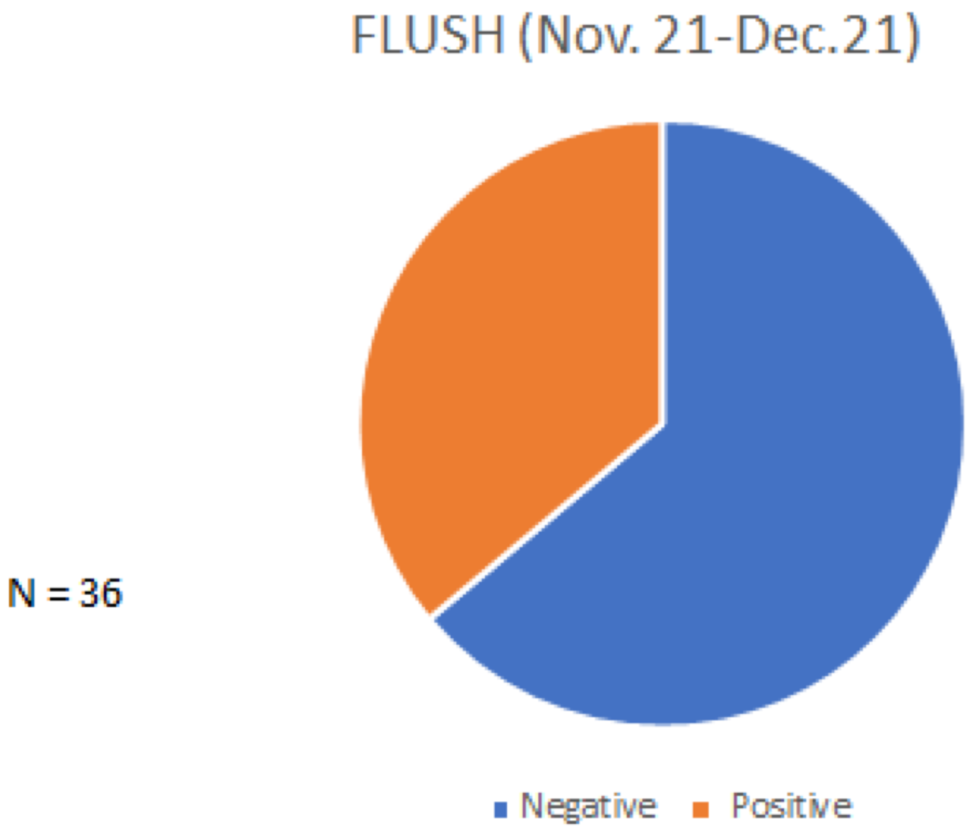


Culture – based methods for antibiotic resistant pathogens

DNA Extraction and qPCR for antibiotic resistance genes

Detectable MRSA in surfers is strongly dependent on the water quality

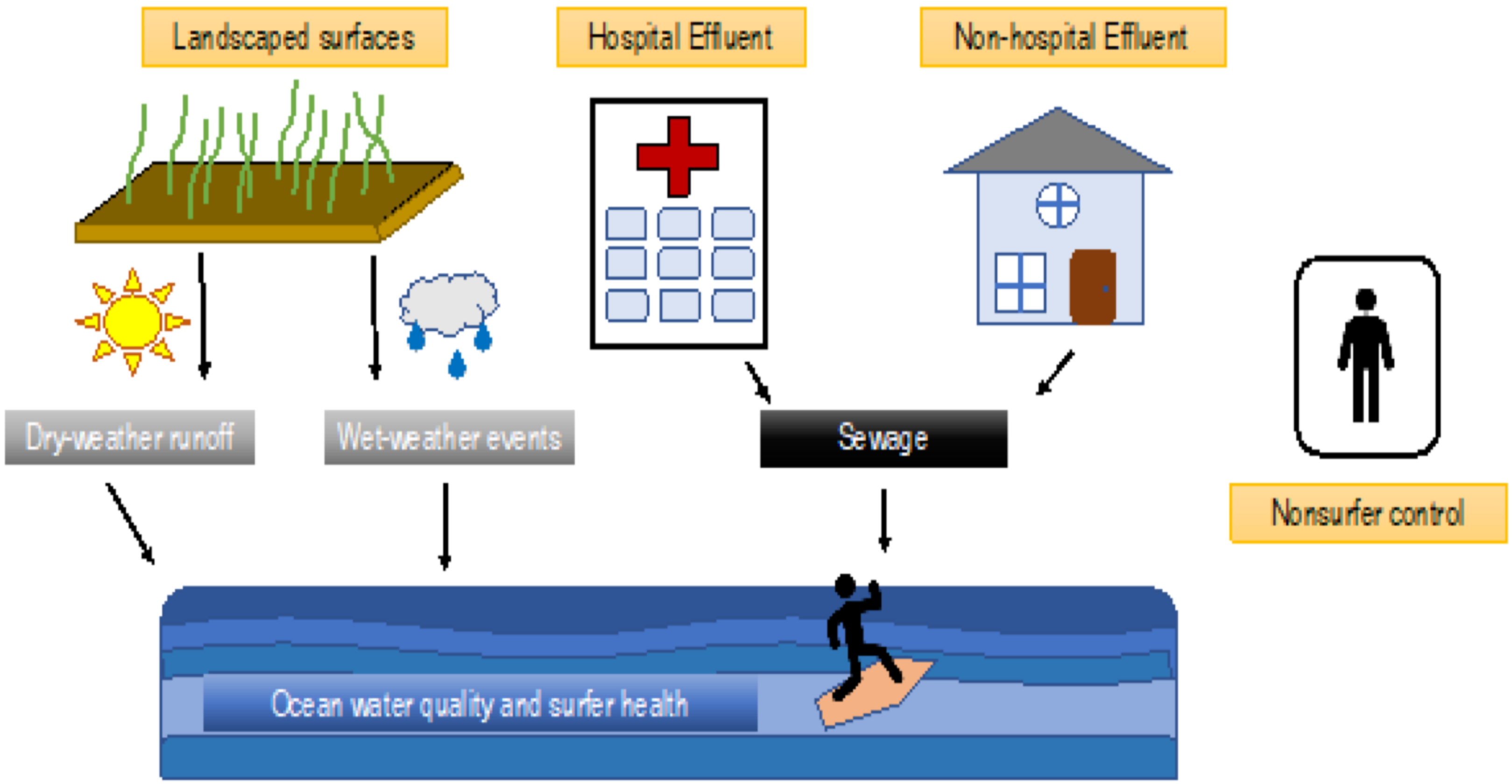


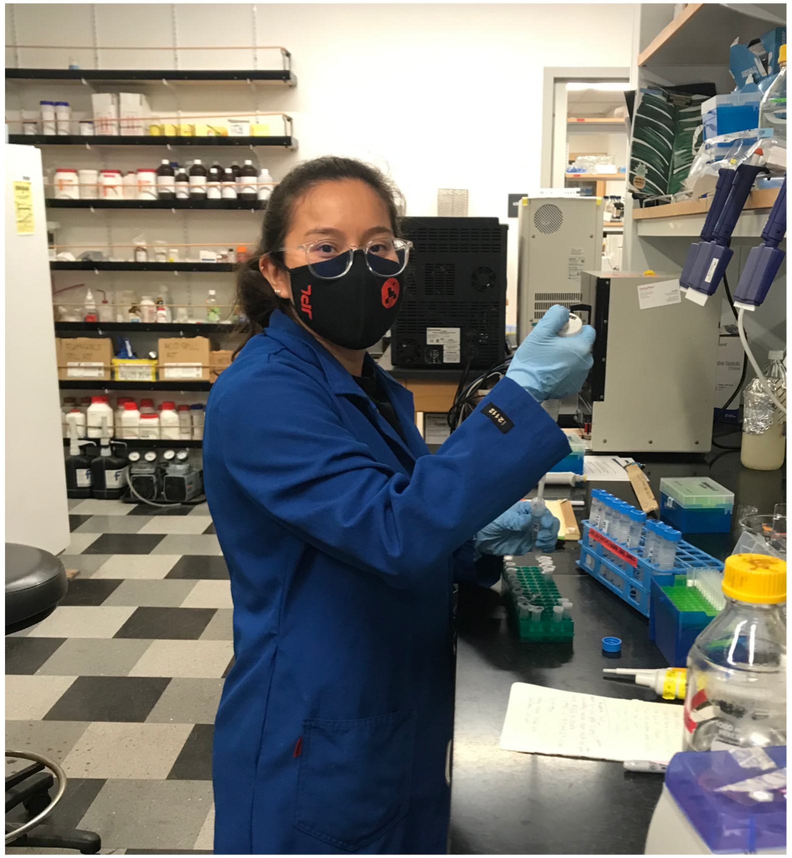


Current work: Is the MRSA livestock-associated?

- 18 MRSA isolates sent for whole genome sequencing
  - Preliminary results show both community and health-care associated MRSA from surfers
  - Hospital-associated shown to be multi-drug resistant in plates

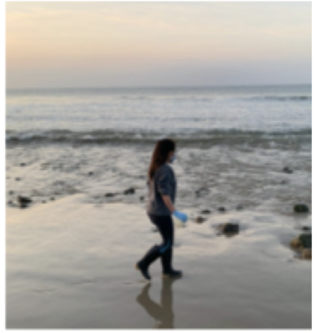
Investigating connectivity between sources and reservoirs



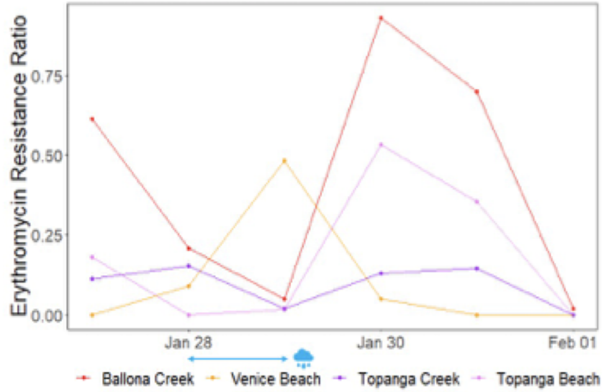


Study Sites:

Sampling:



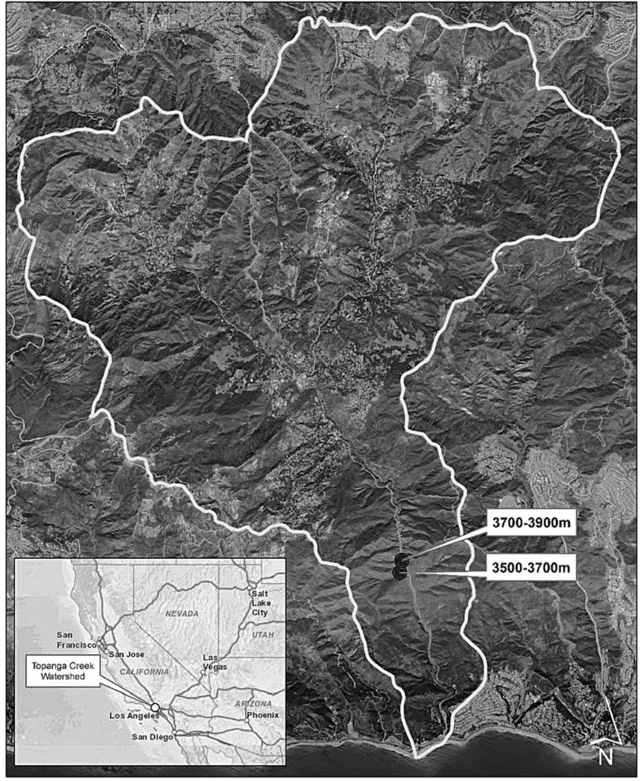
Preliminary Results:

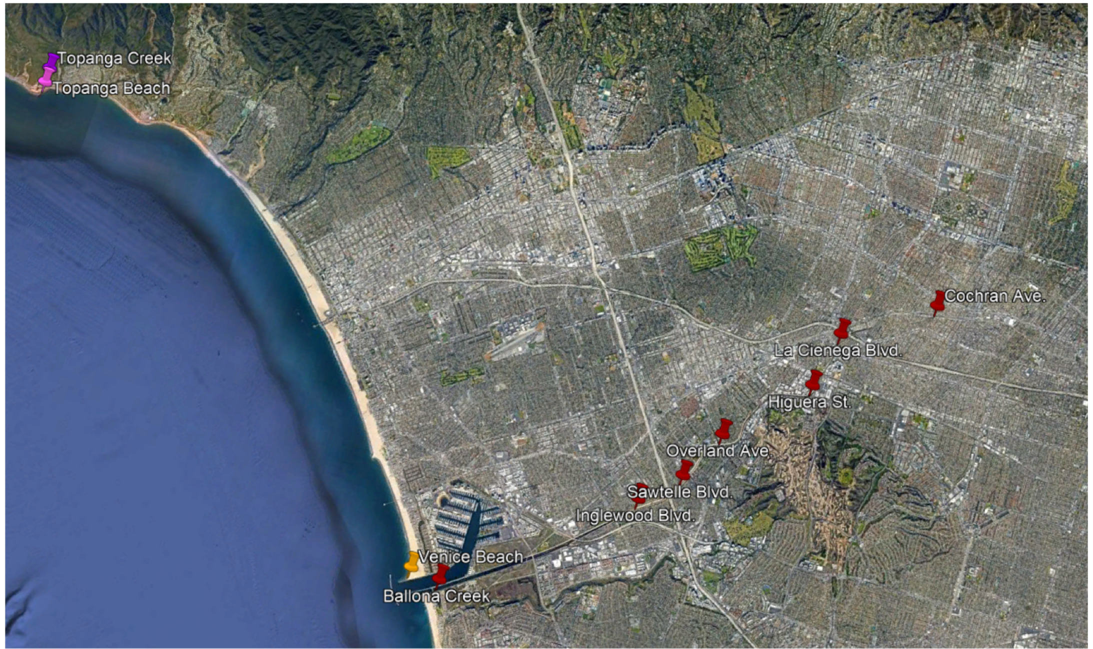


Ballona Creek Watershed Study

Applying a new method to look for hotspots for environmental transfer of antibiotic resistance genes and presence of clinically relevant antibiotic resistant pathogens

Research questions



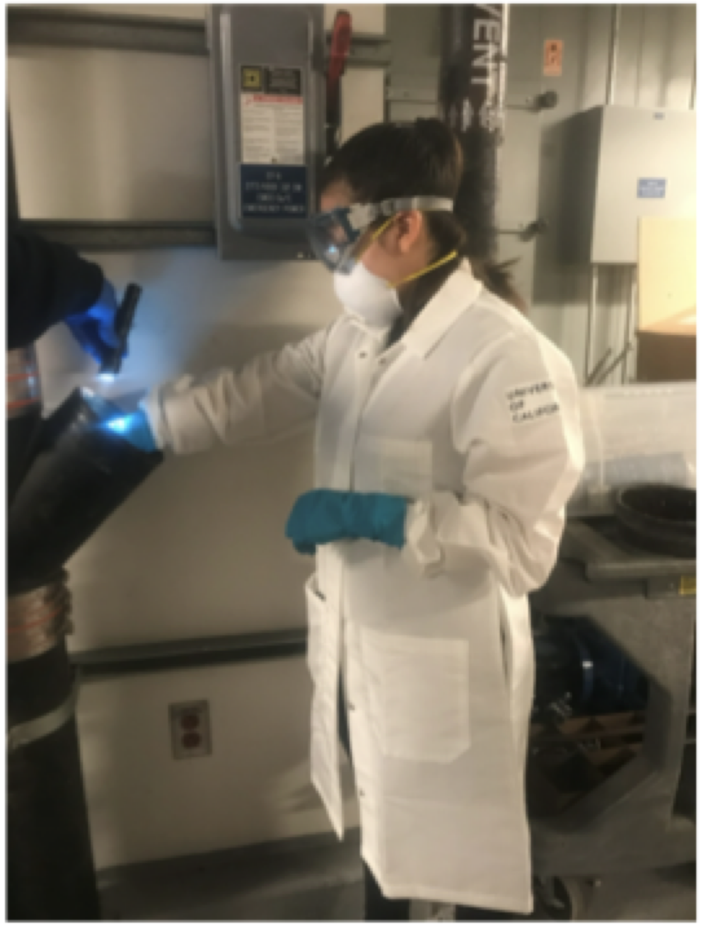


1) How do ARGs and pathogens vary from the headwaters to the outlets of two coastal watersheds with **dramatically different levels of urbanization**?
2) Will the highly anthropogenically-impacted watershed have **a greater number of clinically relevant ARG-taxonomy associations** compared to a mostly undeveloped watershed?
3) Will the **Shannon diversity of ARGs differ** between watersheds with varying land uses and along an urbanization gradient?
4) Will **ARG gene mobility be elevated** in the highly anthropogenically-impacted watershed?
5) Can the levels of crAsspage, HF183, and certain ARGs at a particular site be used to indicate **a hotspot for horizontal gene transfer** (HGT)?

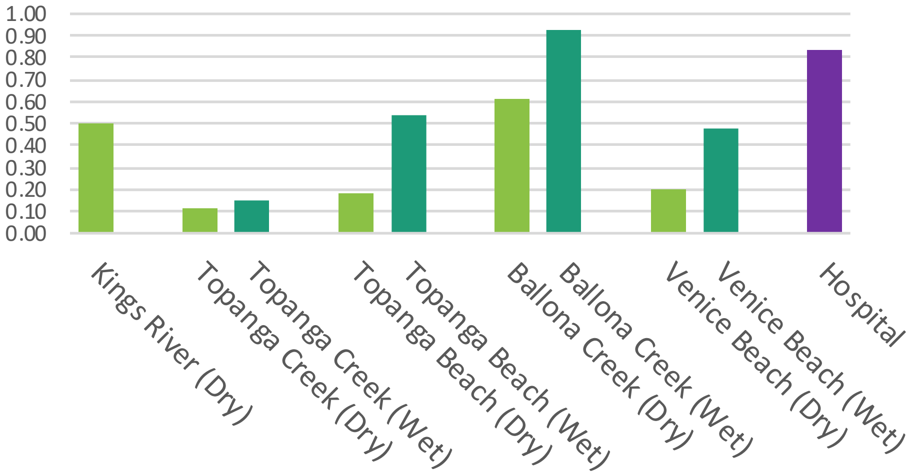
Hospital Study

Study Site:

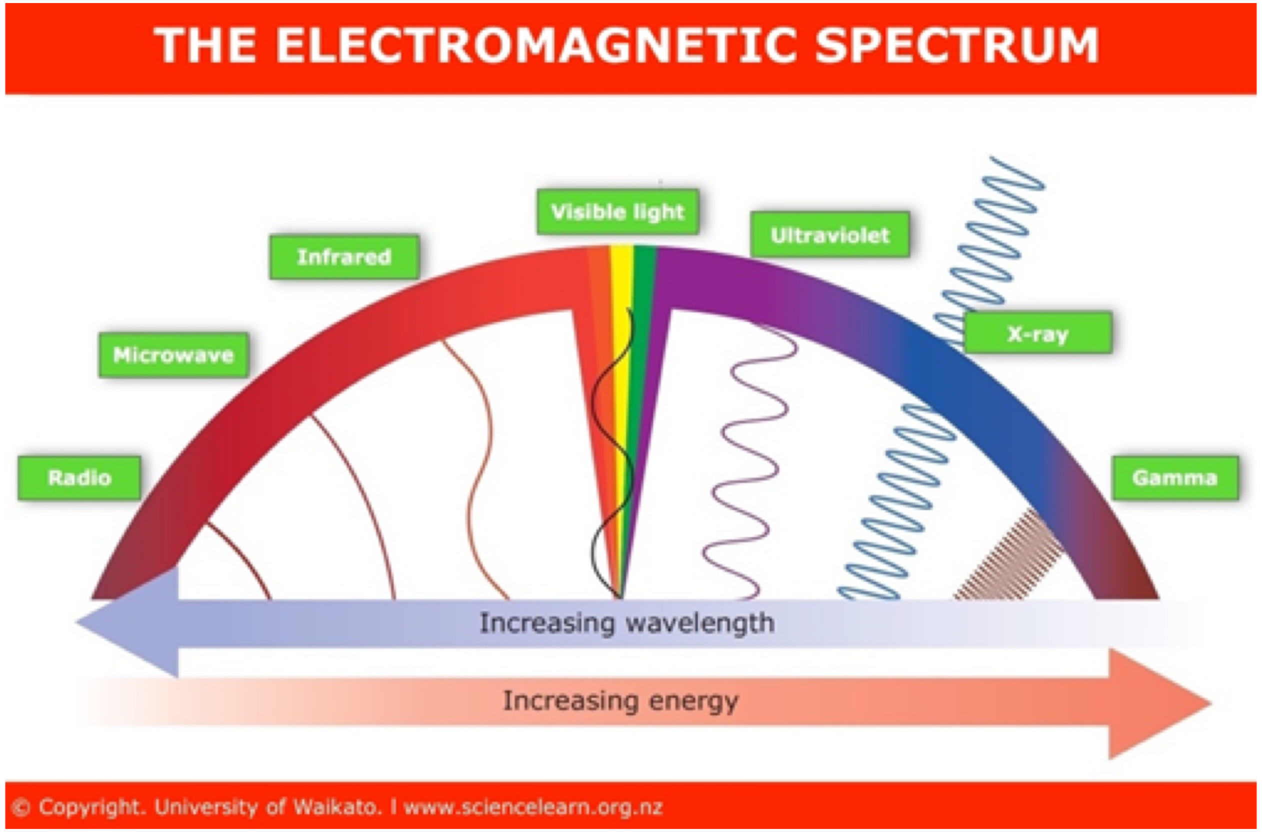
Sampling:

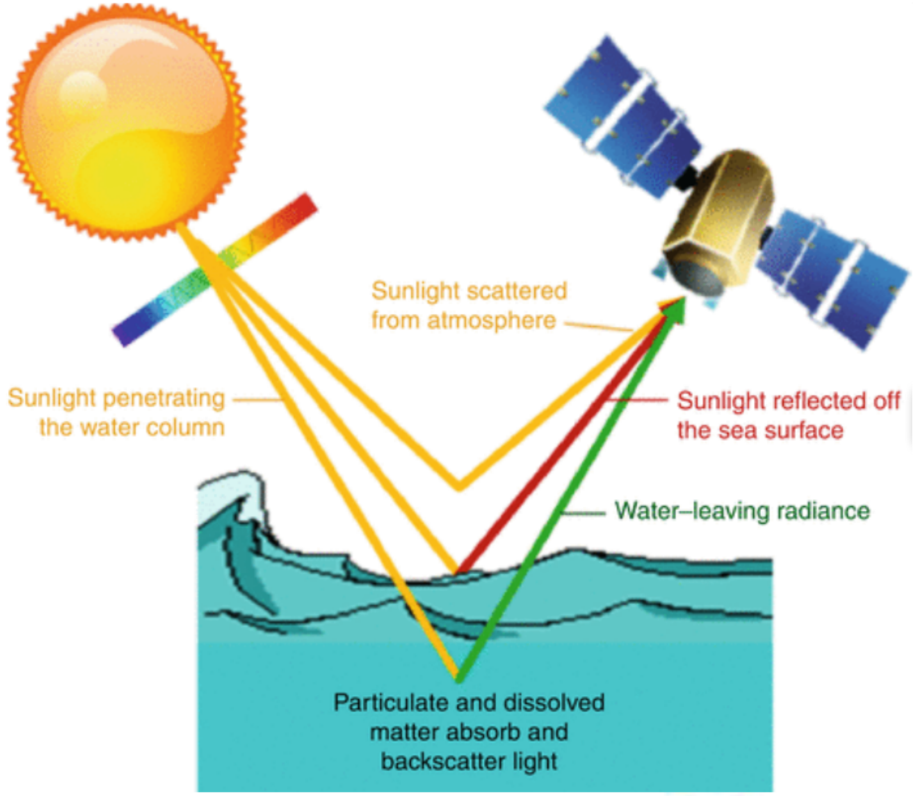


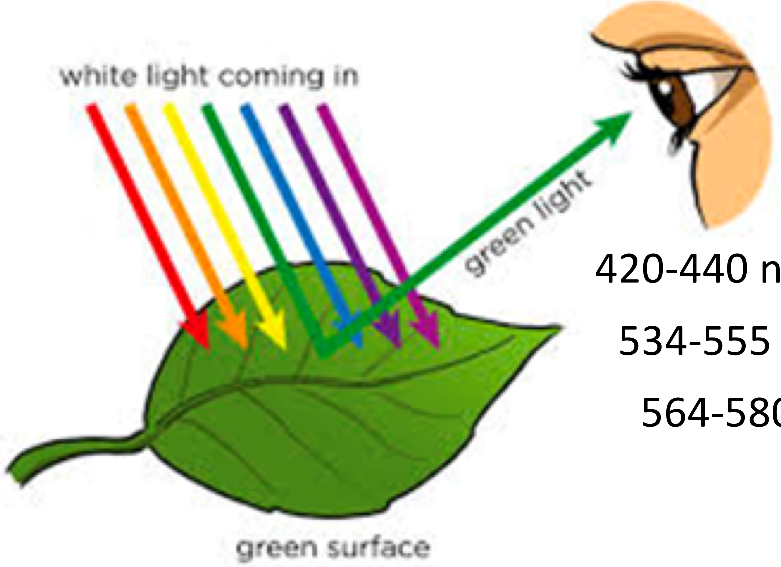
Maximum Erythromycin Resistance Ratio



What role due hospitals play as sources of antibiotic resistant pathogens and antibiotic resistance genes to the environment?







420-440 nm (blue)

534-555 (green)

564-580 (red)

Image Credit: Xuan Zhu, Siyavula.com

Rupert Bay in Quebec (Canadian province) on July 30, 2016

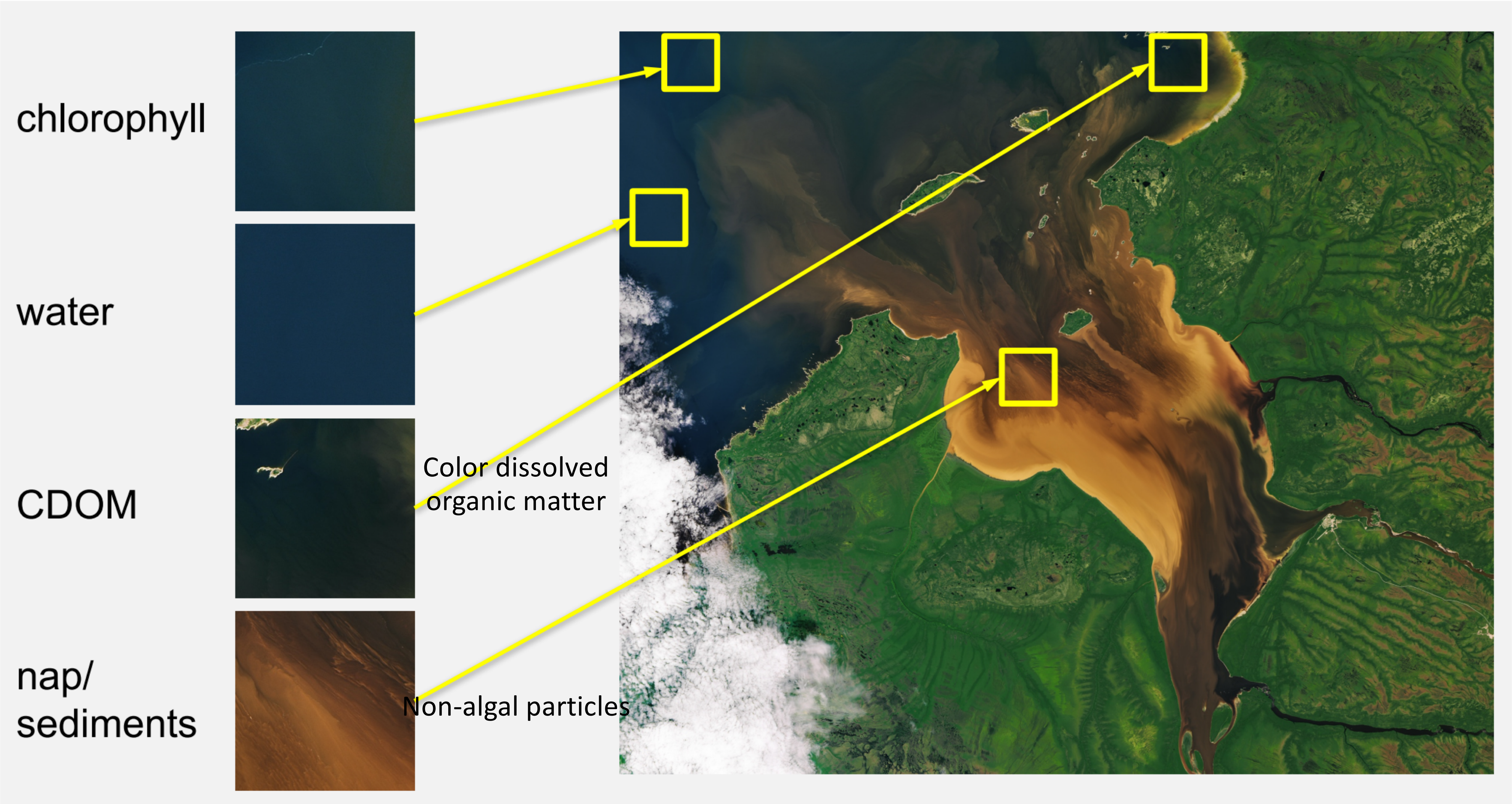


Image Credit: NASA Earth Observatory images by Joshua Stevens, NASA ARSET

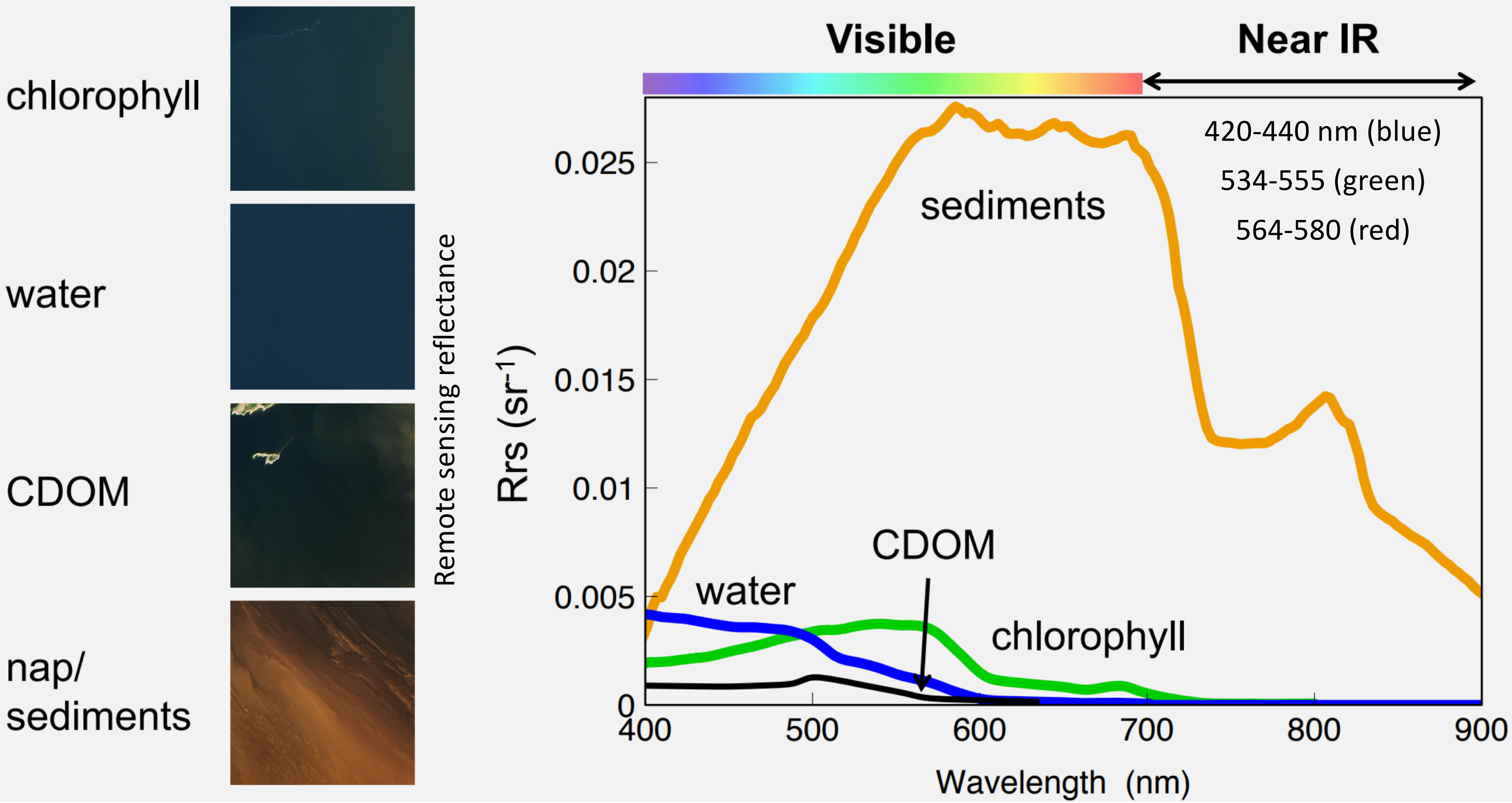
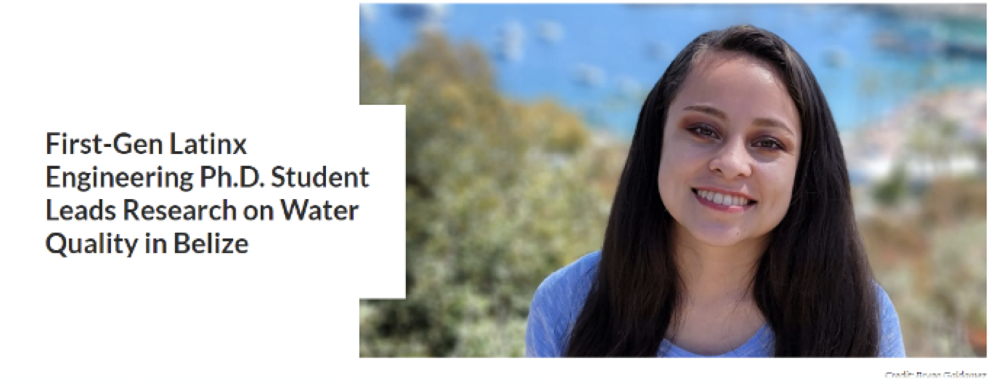
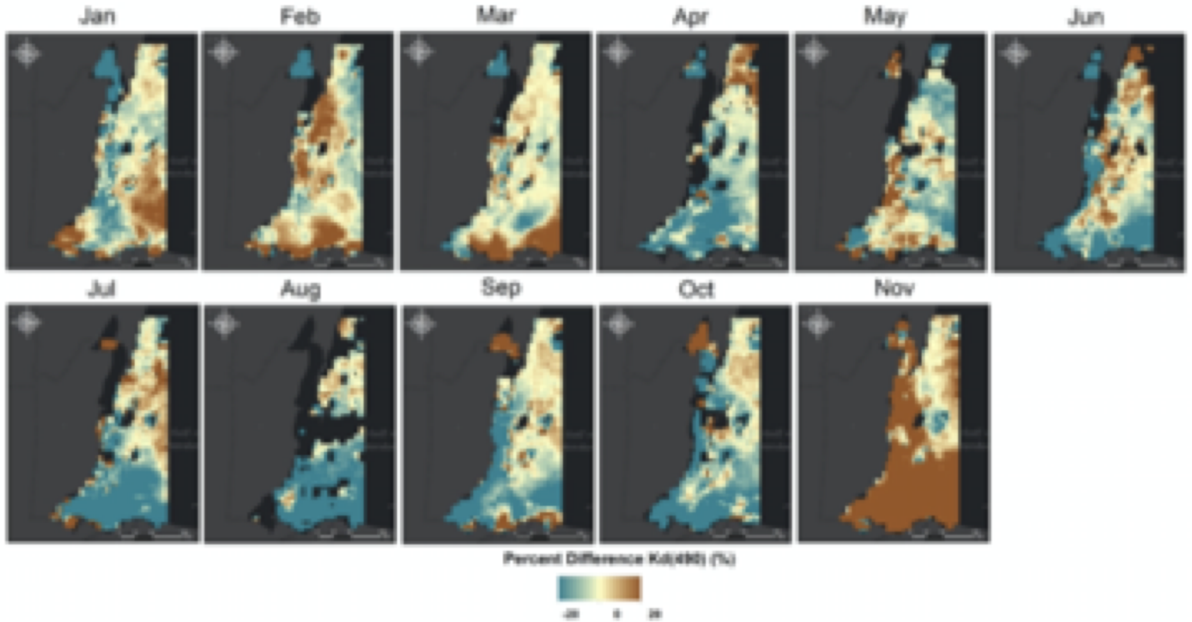
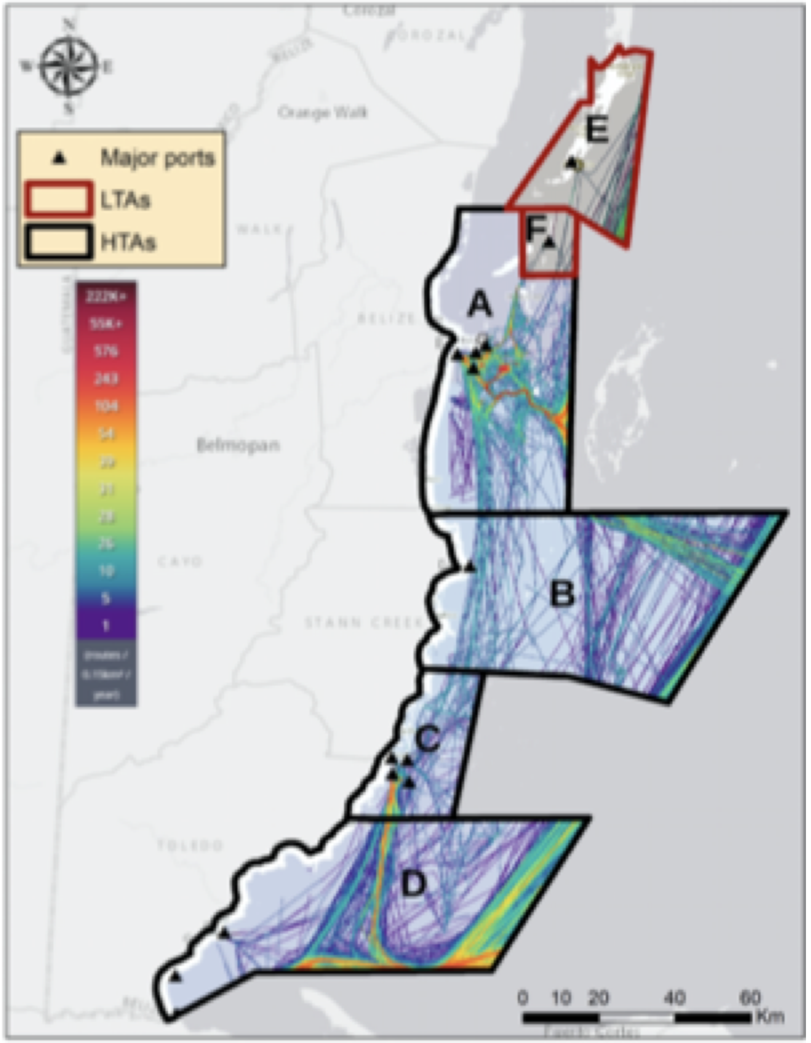


Image Credit: NASA ARSET

Water in Belize better after COVID-19 shutdown but worse after hurricanes



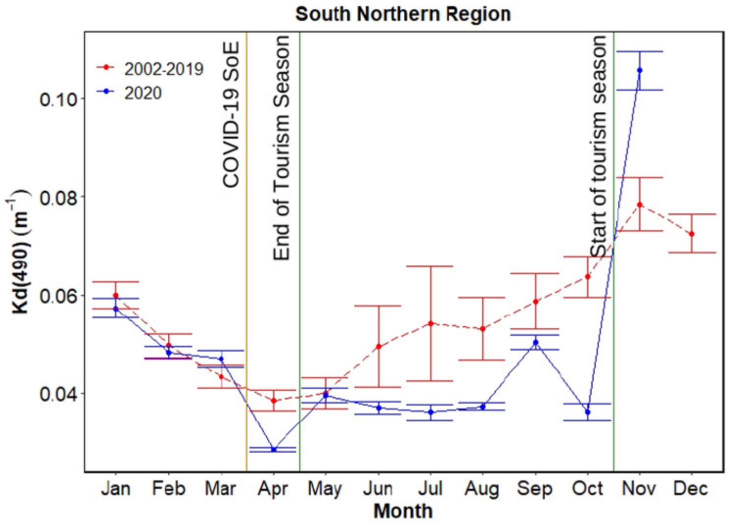


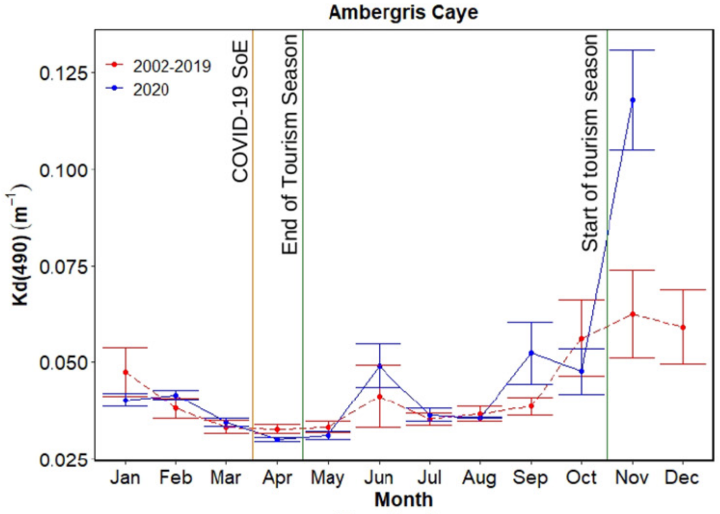


frontiers in Marine Science

BRIEF RESEARCH REPORT
published: 05 May 2021
doi: 10.3389/fmars.2021.648522

Effect of COVID-19 Anthropause on Water Clarity in the Belize Coastal Lagoon





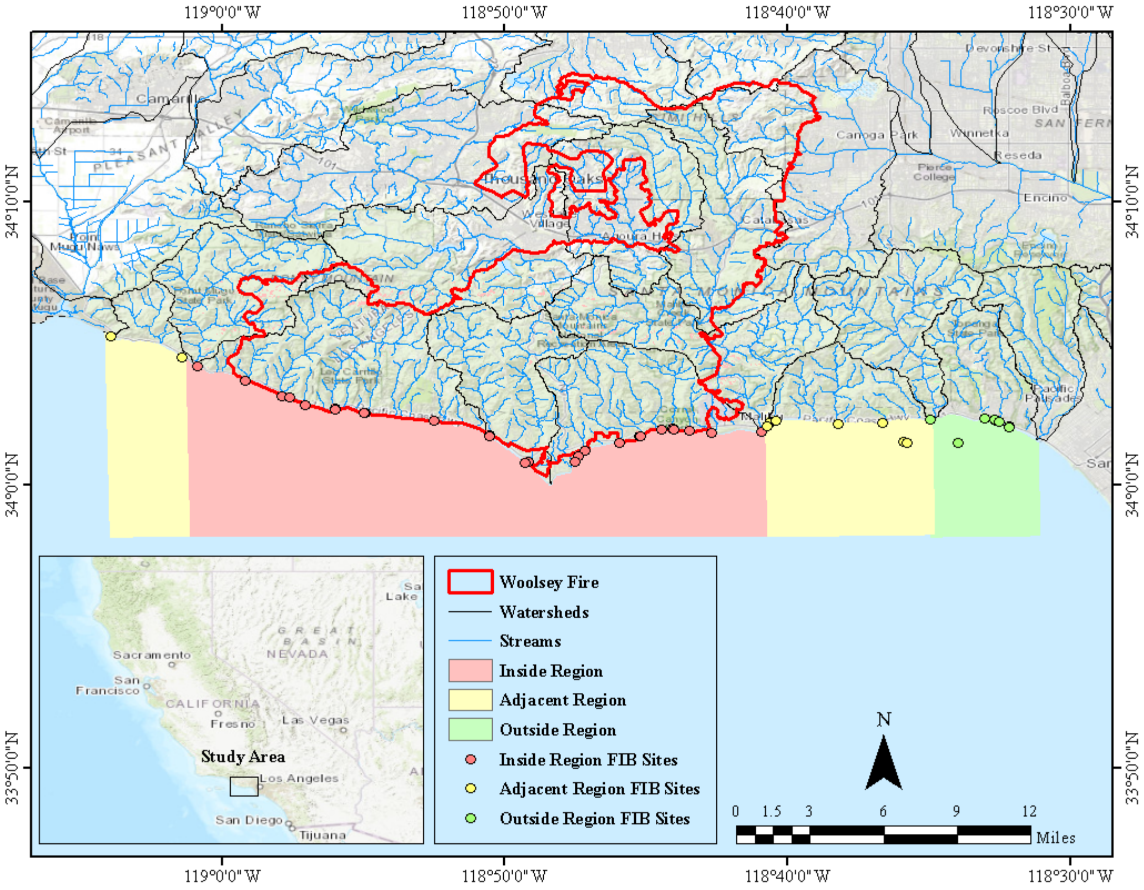
Current work: Source identification and antibiotic resistance in LA River Watershed and Belize River Watershed

Funded by JPL to collect water samples in Belize w/ Jenny in the winter to test a **framework for assessing antibiotic resistance in the environment**

Credit: M. Phillips, D. Arzu, M. Rudresh, C. Wheelock

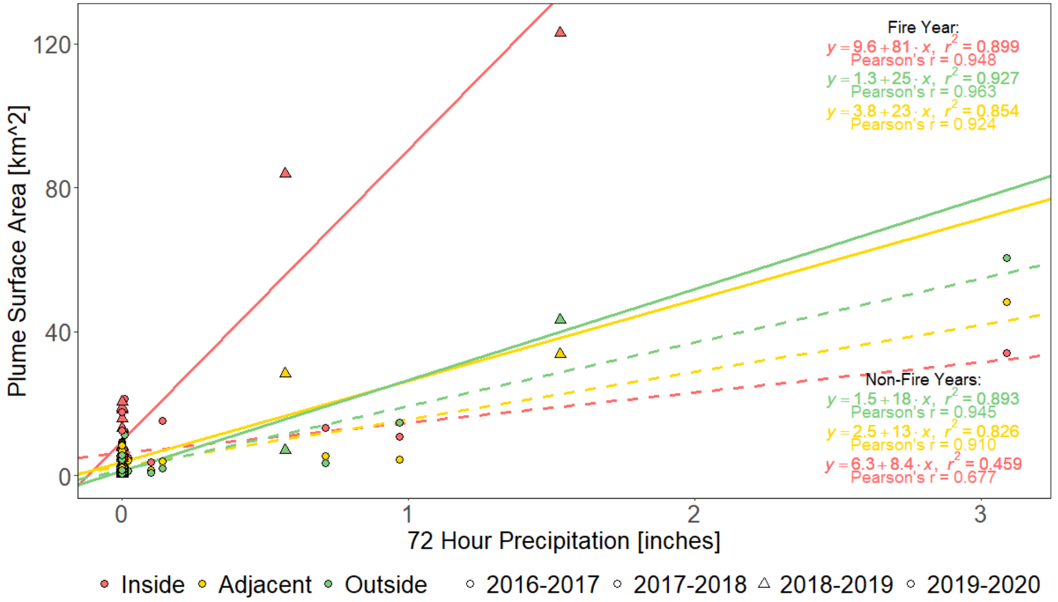
Woolsey Fire Study

Study Sites:



Results:

- Turbidity plumes and fecal indicator bacteria increase after Woolsey Fire

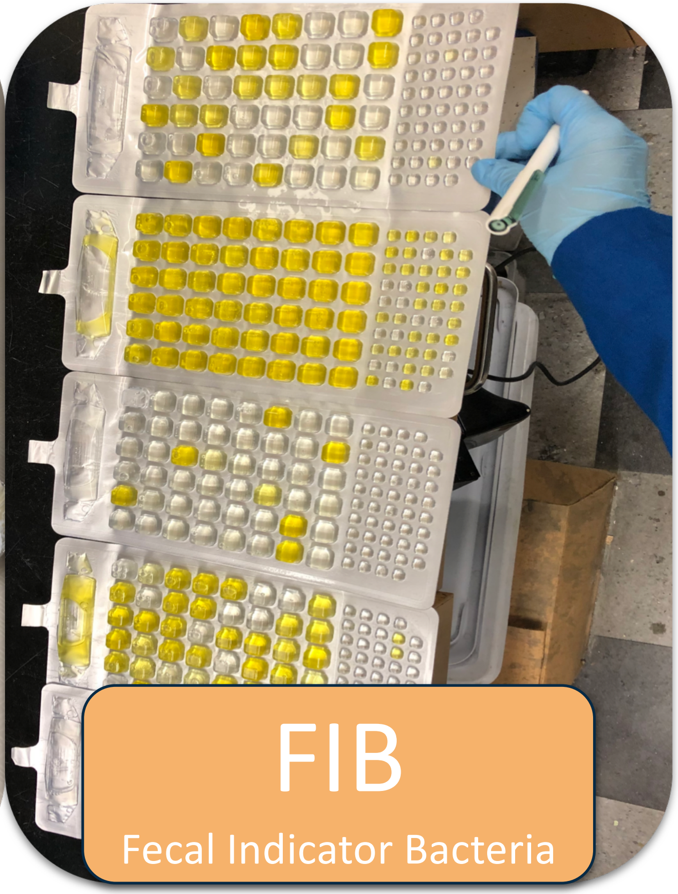


Manuscript Provisionally Accepted

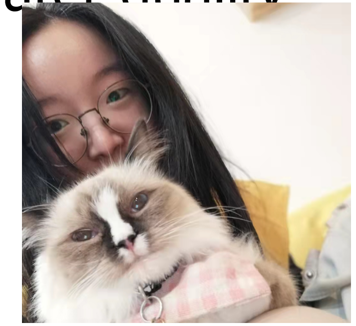
Heal the Bay

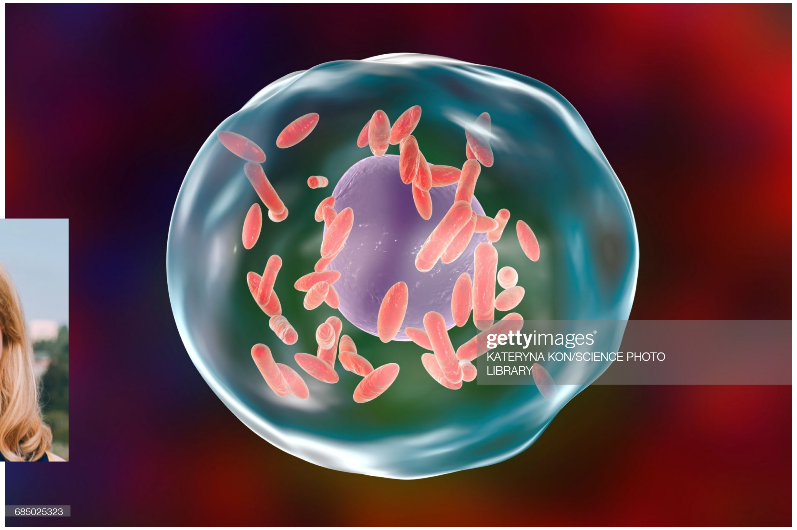
Using Satellite Data for Coastal Water Quality Monitoring

In Situ



Getting in situ coastal water quality data (e.g. TSS, FIB, Absorbance, Turbidity) and compare with satellite data (ACOLITE-dogliotti/nechad2016, GEE — Sentinal2 & Landsat8), to find the correlation and prove satellite data could be used for water quality monitoring.

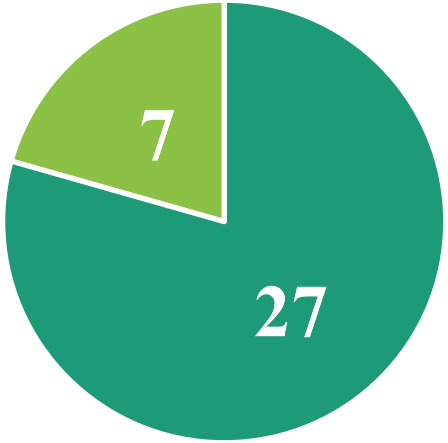




Q fever

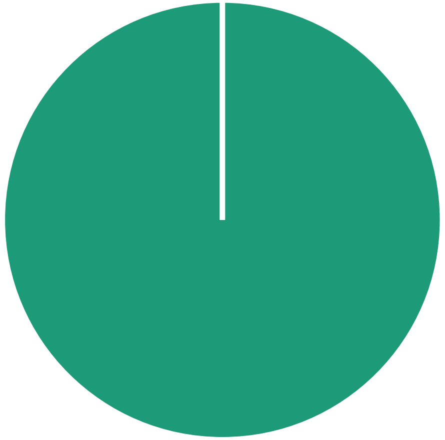
Fertilizer

Total 34 samples



Background

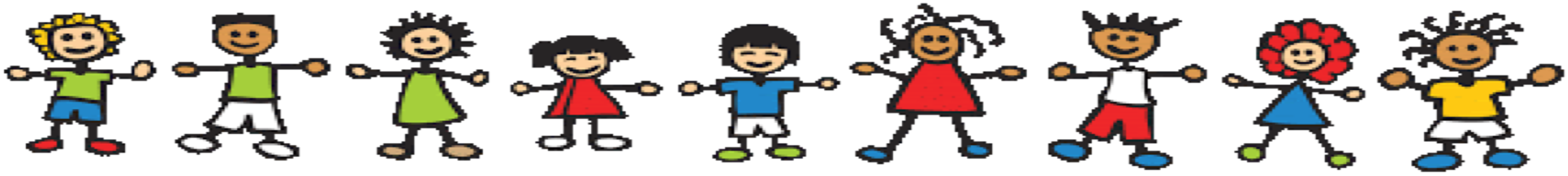
Total 8 samples



- Q fever is caused by the bacterium *Coxiella burnetii that* naturally infects some animals, such as goats, sheep, and cattle
- Sampling commercial fertilizers and environmental soils for *C. burnetii* screening (*IS1111*)

Assessing Cumulative Lead Exposure in Los Angeles Children

Naomi Adams



Research questions

Understanding the cumulative impacts of lead exposure for children in Los Angeles

- How to engage LA communities in a comprehensive lead exposure assessments in the age of COVID-19?
- What are the relative contributions from each contaminated medium to the total exposure of lead to children in LA?
- How can this information help develop a systems thinking framework for lead remediation.

What is Lead?

<u>Features</u>

- ➔ Soft
- ➔ Malleable
- ➔ Ductile
- ➔ High density
- ➔ Low melting point
- ➔ Long half life in soil

<u>Applications</u>

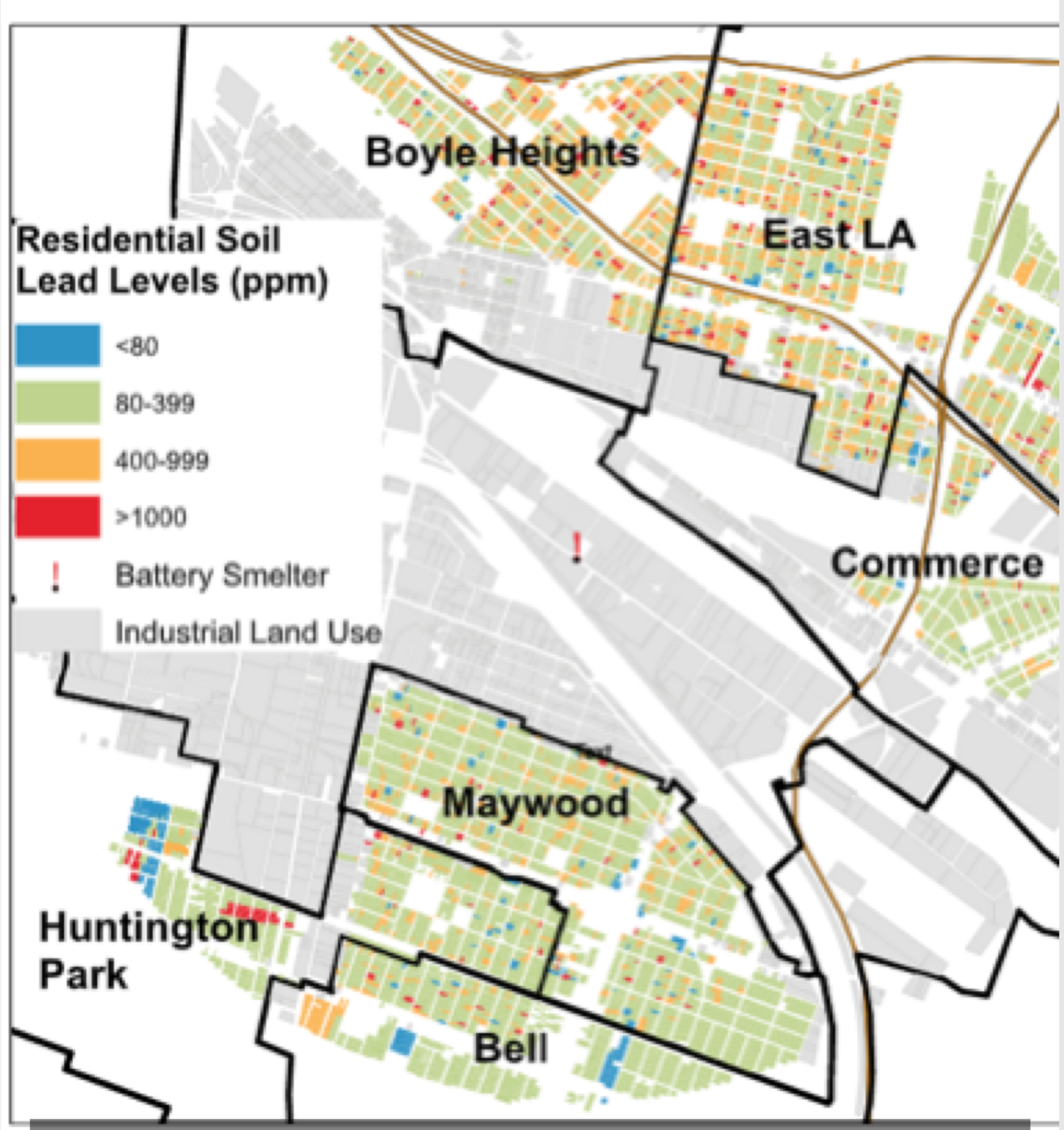
- ➔ Gasoline
- ➔ Paints
- ➔ Pipes
- ➔ Batteries
- ➔ Bullets

Lead Exposure and Public Health

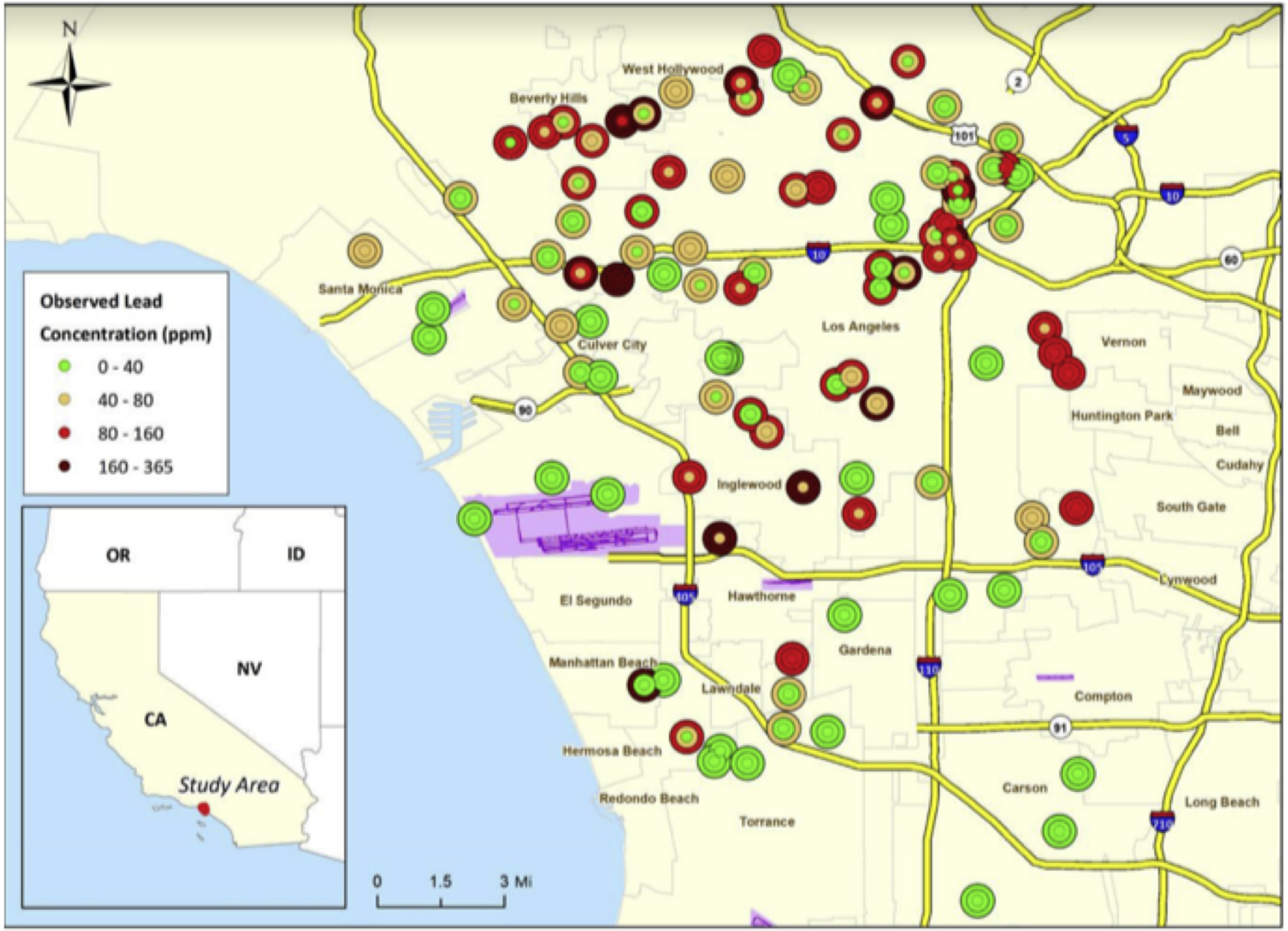
- There is no safe level of Lead exposure
- Low levels of Lead exposure could cause cognitive deficits, neurodevelopmental delays, and psychological impairments.
- A blood lead level of 10 ug/dL leads to a drop of 3-5 IQ points, and this loss results in a slowing of the learning process and reduced memory capacity. In addition to this loss of IQ, the learning process is also impaired by an increase in learning disabilities, hearing loss, attention deficit disorders, and hyperactivity (Washington, 2019)

Lead in Los Angeles

- Pb in LA is product of the city's long history of industrialization and urbanization
- In Southern California 100 regulated facilities emit more than 2600 pounds of lead annually, according to AQMD
- More than 60% of homes in Los Angeles have been built before the 1970s.



Residential neighborhoods near the battery smelters and measured soil lead levels based on sampling by the California Department of Toxic Substances Control (Johnston, 2018).


N
Observed Lead
Concentration (ppm)
0 - 40
40 - 80
80 - 160
160 - 365
West Hollywood
Beverly Hills
Santa Monica
Culver City
Los Angeles
Vernon
Maywood
Huntington Park
Bell
Cudahy
South Gate
Inglewood
Lynwood
El Segundo
Hawthorne
Gardena
Manhattan Beach
Lawndale
Compton
Hermosa Beach
Redondo Beach
Torrance
Carson
Long Beach
OR
ID
NV
CA
Study Area
0
1.5
3 Mi
101
10
405
110
105
91
710
90
60
5
2

Hung, 2018

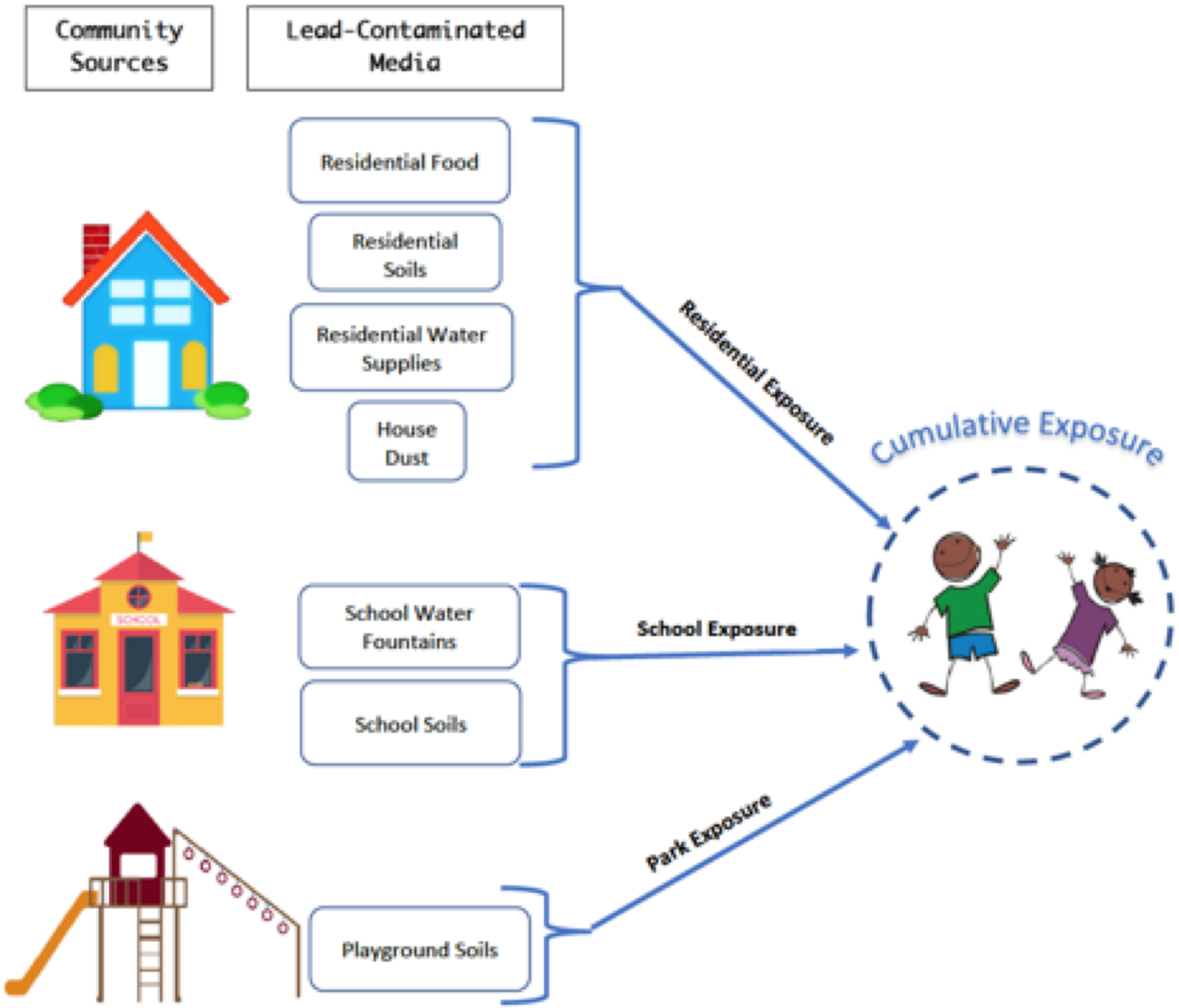
Childhood Lead Poisoning

- Lead poisoning is one of the most common and best-recognized childhood diseases of toxic environmental origin
- Children are some of the most susceptible to lead poisoning due to their phase of growth and development as well as behavioral patterns
- The annual economic toll from lead exposure in California alone is estimated to result in lost earnings of $8–$11 billion dollars over the lifetime of children.

Project Significance and Impact

- In California, the exposure risks children face can vary wildly by neighborhood.
- There are well-documented disparities in lead poisoning across racial and socioeconomic status that persist today.
- Communities living near Exide are more than 90% Latino and that rank among the top 10% of most environmentally burdened areas of the State, according to CalEnviroScreen 2.0.

Research Framework



Progress on Lead Exposure Research

- Collection of over 200 soil samples all around LA with varying land use
  - p-XRF
  - Mail-in Sampling Kits
- Collaboration with Early Head Start and Community-Based Organizations

Classes

- 19 Foodprint: Connections between food and the environment
- **153 Introduction to Environmental Engineering Science**
- 154 Chemical Fate and Transport in the Environment
- 155 Unit Operations and Processes for Water and Wasterwater Treatment
- 156A Environmental Chemistry Laboratory
- 156B Environmental Operations and Processes Laboratory
- 157B Design of Water Treatment Plants
- 157C Design of Wastewater Treatment Plants
- C159 Green Infrastructure
- 164 Sustainable Waste Management
- M165 Environmental Nanotechnology
- M166 Environmental Microbiology
- 199 Research projects with faculty/graduate student mentors